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# Another Tasmanian Paradox: Clothing and Thermal Adaptations in Aboriginal Australia

Ian Gilligan

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# Abstract

This work explores the nature and extent of the use of clothing in the pre-colonial Australian Aboriginal population. Anthropological reviews have indicated that while a total absence of clothing was the usually the case, garments were sometimes worn. Clothing appears to have been used almost exclusively for reasons of warmth, and the geographical distribution seems to be consistent with an essentially thermal pattern. Clothes are documented in the cooler southern and southeastern areas of the continent, and more frequently in the cooler seasons. The garments were of a single-layer, draped variety, hung loosely from the shoulders. They generally took the form of capes or cloaks, and were manufactured from marsupial skins, mainly kangaroo or wallaby hides, or a number of opossum furs sewn together. These items served additionally, and sometimes primarily, as mats or rugs, and as bags or containers, the latter especially among women, who also used them to carry their infants.

However, one problem with this ethnographic picture is that the Aborigines of Tasmania apparently made less use of clothing than did their counterparts across Bass Strait. This "Tasmanian clothing paradox", referring to the fact that the Tasmanians would be expected to use at least as much clothing as Aborigines on the southern mainland, forms the focus of this study.

The paradox alludes to the 1977 "Tasmanian Paradox" paper by prehistorian Rhys Jones. In this he discussed the "problem" posed by the ethnographic and archaeological records available at the time. In his view, the cultural repertoire of the Tasmanian Aborigines was diminished in comparison to mainland Aboriginal Australia, yet there was no evidence that Tasmanians were less successful in adapting to their environment. The relative deficiency in clothing parallels Jones' paradox. It raises the question of why, if Aboriginal use of clothing was essentially thermal, the Tasmanians could manage with less clothing despite their colder environment.

A systematic analysis of the ethnographic record forms the main study. It comprises first-hand observations of the use of clothing by Aborigines prior to, and in the decades following, the beginning of the colonial era, in relation to latitude and various meteorological indices. The results confirm both a strong thermal pattern of clothing use in the Aboriginal population, and also an attenuation of this pattern in Tasmania. The Tasmanian clothing paradox is thus a real phenomenon, and the question is whether it can be resolved.

The approach adopted in addressing this question is to review the principles of human thermal physiology, including clothing physiology and thermal aspects of morphological variation. It emerges that the latter may be crucial. A separate study indicates not only that morphological variation within the mainland Aboriginal population manifests strong thermal trends, but also that the Tasmanian Aborigines may have developed greater morphological cold adaptations. These, it is suggested, could help to account for the capacity of the Tasmanians to manage with less clothing.

A third study is included, in which thermal factors are explored in relation to one of the archaeological challenges posed by the Tasmanian Aborigines, namely their utilisation of cave sites in the remote southwest region of the island during the latter part of the last ice age. Using palaeoenvironmental data to reconstruct thermal conditions during the late Pleistocene, and focusing on wind chill levels in relation to human cold tolerance thresholds, the findings suggest thermal factors were an important aspect that affected past human behaviour in the region. The archaeological record of Tasmania also suggests that humans in the region may have utilised more clothing at that time, and then reduced their use of clothing as temperatures increased in the early to mid-Holocene.

In summary, thermal contingencies are found to be relevant to both the ethnographic and archaeological records in Tasmania. One implication is that prehistoric clothing can be rendered more visible archaeologically by the application of thermal physiology and palaeoenvironmental reconstruction. Moreover, as Jones intimated, the Tasmanian late Pleistocene archaeological record invites comparison with those of other regions, including middle latitudes in the northern hemisphere. It is suggested that such comparisons could be especially productive with respect to thermal adaptations. Wider implications relate to theories about the origins of clothing in general, and the repercussions of its development for some of the major prehistoric trends in human cultural development.

# CONTENTS



## PART ONE: BACKGROUND



## PART TWO: STUDIES

### STUDY 1: ETHNOGRAPHY

# List of Figures

## List of Tables

## Acknowledgements

This monograph is essentially a published version of my M. Phil. thesis completed in 2005. In preparing it for publication, I have resisted the temptation to substantially revise the text. The one exception is the inclusion of a narrative review of the early ethnographic record (Chapter 2), omitted from the thesis due to the word limit. A project of this nature is always a work in progress, and I suspect there would be little prospect of ever reaching a "final" draft. Moreover, since the time of its submission, some of the analyses are being revised, to varying degrees, in the process of writing a series of papers (Gilligan in prep., in press, submitted; Gilligan and Bulbeck submitted). These latter can serve as updated versions of the respective sections. This volume seeks more to capture what was one of the main intentions of the thesis as a whole, namely, to demonstrate the value of bringing together relevant evidence from different data domains to bear upon a single issue.

I wish first to thank my thesis supervisor, Peter White, at the University of Sydney. Without his dedication and constant attempts to keep me focussed on the topic, writing the thesis would never have reached completion. While he may not have been entirely successful in preventing me from pursuing certain tangents to the possible detriment of the work as a whole, its mere completion stands as a testament to his supervisory skills. I'd also like to express my gratitude to the two examiners, Richard Cosgrove and Richard Wright, for their generous and invaluable comments.

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Parts of the section on human cold tolerance have been modified and updated from material written by myself for an unpublished manuscript prepared with Michael Walker, while he was a Senior Visiting Research Fellow at the University of Oxford in 1994 (Gilligan and Walker n.d.). A number of Michael's colleagues read drafts of that manuscript and offered comments, and I would like to express my appreciation to them. They include Derek Roe (Pitt Rivers Museum) and Tony Boyce (Department of Biological Anthropology) at the University of Oxford, Clive Gamble (University of Southampton), and Will Roebroeks (University of Leiden).

The archaeological section (Study 3) is based on a preliminary paper presented in the Plenary Session at the Australian Archaeological Association (AAA) annual conference at Jindabyne in December 2003. The morphology section (Study 2) is based in part on a poster presented at that conference, and was presented in the Adaptations session at the Australasian Society for Human Biology (ASHB) annual conference in Canberra in December 2004.

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The views and interpretations expressed are, unless otherwise indicated, solely those of the author.

## Definitions

The term "clothing" is employed throughout this work in a simple and straightforward sense. The main qualification is a distinction between "simple" and "complex" clothing, as discussed later. Clothing is, however, highly ambiguous with respect to items such as girdles, waistbands, and so on. This problem becomes acute for the ethnographic study (Study 1). In this study, for purposes of quantitative analysis, the early European and colonial-era descriptions of the appearance of Aboriginal people are categorized as either "clothed" or "naked".

There exists a dialectic on clothing and nakedness, and there is an ongoing argument in the literature as to the definition of clothing which takes place within that context. This is the province of cultural theory, anthropology, sociology, art history, and dress studies (e.g. Gill 2002), and the present discourse is not intended to encroach upon that territory. It is necessary, however, to highlight one issue. This is a tendency to insist that clothing cannot or should not be distinguished from other forms of bodily decoration, modification, or ornamentation. In turn, this leads to the assertion that there can be no such thing as "nakedness", that the term is a social construct, rather than a physical state of unclothedness. The cultural and social significance of clothing in contemporary Western society, for instance its connections with concepts of decency and even humanity itself, are seen as being invested onto clothing by culture, rather than being consequent upon the habitual use of clothing (at least in its "complex" guise).

The main concern in the present context is that these theoretical positions result in the impossibility of examining the prehistoric origins of clothing, since by definition it has always existed, or at least it has existed for as long as humans have existed. Equally, it becomes meaningless to examine whether or not Aboriginal people wore clothes, and almost inherently offensive to describe them as being unclothed or naked, as this denies or demeans their use of body decoration as "clothing". These issues are summarised in the opening chapters of Barcan's (2004) *Nudity: A Cultural Anatomy*, and the following excerpts illustrate the potential problems this approach can entail for the present study:

> *The natural state is, in fact, unnatural, if we accept that there have never been human societies in which the body has remained totally unclothed, decorated or adorned*
>
> (Barcan 2004: 2)

> *Whatever it is, the nude body is never naked, if naked means stripped of meaning, value and political import*
>
> (ibid: 9)

> *The question of what counts as clothes is by no means frivolous; it can have profound consequences. For example, European explorers didn't always consider the body ornamentation and coverings worn by the Australian Aborigines to be "clothing." Considering Aboriginal people to be undressed was part and parcel of a more general colonial understanding of Australia as "uninhabited," "unimproved," still to be civilized*
>
> (ibid: 16-17)

Without embarking upon a separate thesis on the subject of defining clothing, it may be stated at this point that some of the assertions underlying the above approach are contestable. The metaphorical meanings of clothing and nakedness in Western culture are not denied, nor is the historical fact that the typical nakedness of Australian Aborigines was among the characteristics, along with their typical lack of permanent habitations, that was exploited by colonists to denigrate them and deny their status as original inhabitants. It will hopefully be conceded that, regardless of how defensible or otherwise is the restricted definition of clothing here, it is at least one appropriate to the present aims, and may even be necessary to properly address those aims.

For Aboriginal people, the adoption (or imposition) of European-style clothing represented a fundamental rupture of their traditional values and identity, and it was a key material marker of their loss. From their perspective, it was not such much the acquisition of clothing that mattered – in some areas they had used indigenous garments at times – but rather it was the loss of their habitual nakedness that went along with it. Prior to white settlement, there had been no such thing as "nakedness". It was a constant psychological state for them, even when they might throw a cloak over their shoulders to keep warm. The latter held no par-ticular social connotations, and to denote a special state of being without a garment made no more sense than for Europeans to have a distinct term for being without a watch, or an umbrella. The regular use of European-style clothing along with all its profound connotations, however, was a different matter entirely:

> *There are no words that I have come across in our indigenous languages to describe nakedness. Prior to the colonists' invasion of our territories there was no reflection of our nakedness. The reflection of nakedness came with the other, the clothed colonising peoples... Nakedness was our identity and culture. What is our culture now? Still nakedness? Yes it is, but it lies suppressed beneath the covering layers of colonialism... This was more than a dispossession of land; it was a dispossession of law, and the disposal of nakedness*
>
> (Watson 1998: 2)

Among the Tasmanian Aborigines, while a number of indigenous words denoting clothing, garments, blankets and so on, are documented, some of which may reflect contact

with Europeans and colonists, there appear to be no indigenous words for a lack of clothing, or nakedness (Plomley 1976: 186-187, 301).

In the present study, even with a more restricted definition of clothing, there arise practical areas of ambiguity between items that can be termed "clothing" and those that better qualify as "decoration" or "ornamentation", and there is often an overlap where a particular item clearly qualifies as both. This issue of what qualifies as clothing is an entire subject in itself, and is not entirely theoretical. Aside from the pragmatic difficulties encountered in categorising ambiguous items for the ethnographic study in the present work, matters of definition become crucial in relation to the question of clothing origins. The prehistoric origins of clothing, and the origins of personal decoration and ornamentation, are not synonymous, although the issues are often confused in the literature, sometimes hopelessly so.

Another, more particular, problem with "clothing" arises in the Aboriginal context. Garments such as kangaroo-skin capes and opossum-fur cloaks were often used not as clothing but as rugs or blankets, or additionally for carrying utensils or food, or to carry infant children. The definition of the item, in other words, might vary according to the context of its use. In some instances it is simply not possible to draw a distinction. Where the item is described as being worn on the body in a particular situation, it can usually be categorised as clothing. Where it is described as a "cloak" or "cape" but is also used as ground covering or as a sleeping blanket, and where it may reasonably be inferred that the item was also used as a garment at other times, it may be is categorised as clothing, even though its use as such may not have been witnessed at the time. Such an approach is not without its problems, but has been considered the less problematical option here, though it is admittedly open to criticism.

An underlying difficulty with the term "clothing" is that, ultimately, it denotes the intended *purpose* for which the item is manufactured or utilised. Clothing is, in a sense, any item that is applied to the body for the purpose of *covering* the exposed skin surface, whatever other purposes it might also serve. Inferring intention is fraught with dangers, not only of a semantic variety. It is nonetheless inescapable, and the Concise Oxford Dictionary refers to this aspect in its definition, "items worn to cover the body". Strangely enough, perhaps the most crucial aspect of this definition is the word "to", which implies a purpose of giving cover to the body. This can lead to dilemmas.

One example is where an Aboriginal person (usually a woman) might be wearing a marsupial-skin item, but with the purpose of carrying it in this fashion whilst on the move, as a matter of convenience, rather than as covering (e.g. Du Portail, in Plomley and Piard-Bernier 1993: 300). The item may actually serve as a rug rather than as a garment. Is this clothing? The answer is probably "no", despite it being worn on the body at the time. This issue is pertinent in the case of the Tasmanian Aborigines, where observers during Cook's visit in 1777 were generally of the view that the women they saw wearing wallaby-skin capes were utilising them solely for the purpose of carrying their infants, and not as clothing (e.g. Ellis 1782: 20).

The term "naked" obviously has numerous problems, and only one example will be mentioned at this point. For the early European visitors and settlers, an important aspect of whether a person was naked or not was whether or not the genitalia were covered, and also sometimes, in the case of females, whether or not the breasts were covered. For this reason, in some cases an Aboriginal person might be described "naked" despite wearing an item of clothing. For example, Baudin describes an Aboriginal man at Geographe Bay 1801 as being "naked from head to foot, except for a skin or piece of bark covering his back" (Baudin 1974: 173). In this case, the man may be categorised as having clothing, and as not being "naked", despite his being referred by Baudin to as "naked from head to foot".

More problems of definition occur with ethnographic descriptions of Aboriginal body shape, or morphology. These are categorised as indicating either a more "linear" or more "stocky" body build. Aside from being confounded with height or stature, which is not relevant in the present study, the descriptors often refer to muscular development in ways that might otherwise suggest "stockiness", which in the context of this work is intended to refer more to overall shape and limb proportions. However, the ethnographic descriptions of body build are incorporated in this work as an adjunct to metrical indices used in the morphology section (Study 2), so the ambiguities are of less concern, whereas the clothing study is entirely dependent upon the ethnographic records. Even so, a paucity of metrical data leads to some reliance upon the ethnographic descriptions of body build for the Tasmanian Aborigines.

Definitions used here correspond to those given in the 2006 edition of the Concise Oxford Dictionary:

| | | |
|---|---|---|
| *clothing* | | *clothes collectively* |
| *clothes* | | *items worn to cover the body* |
| *naked* | | *without clothes; (of an object) without the usual covering or protection* |
| *nude* | • *adj* | *wearing no clothes* |
| | • *n.* | *a naked human figure as a subject in art or photography* |
| *decoration* | | *the process or art of decorating; a thing that serves as an ornament* |
| *ornament* | | *an object designed to add beauty to something; decorative items collectively* |
| *linear* | | *arranged in or extending along a straight line;... involving one dimension only* |
| *stocky* | | *(especially of a person) short and sturdy* |
| *sturdy* | | *strongly and solidly built or made* |

(Concise Oxford English Dictionary, 2006)

## Archaic terms

The ethnographic study has needed to make use of historical records, including verbatim extracts from early European and colonial descriptions of Aboriginal people and their artefacts. These often include descriptive terms which, either explicitly or connotatively, carry derogatory or pejorative meanings. Where redundant in the present context, such descriptors have been edited. However, it is not always possible to do so without unduly disrupting or distorting the sense of the excerpt, or rendering it useless or too ambiguous for present purposes. Moreover, in some cases the derogatory term may carry connotations that are relevant in the present context. For example, the term "miserable" was not infrequently used in describing artificial Aboriginal shelters. One connotation is that such shelter was considered to be actually *inadequate*, in a physiological sense, as protection from the elements. This reveals the observers' ignorance of the physiological role of habituation, a key aspect of Aboriginal adaptation to their thermal environments, not to mention the importance of psychological and perceptual factors in sensory physiology and psychophysics, which can exert a significant effect on perceived levels of thermal comfort or discomfort.

Also, anachronistic ethnographic terms such as "primitive", "savage" and "uncivilised" commonly arise. These are edited where redundant, but again this is not always appropriate or practical, in which case it is worthwhile to note the "technical" meanings that such terms generally denoted. The term "primitive", for instance, also carried notions of "basic" levels of comfort or efficiency, as shown below, and such meanings may not be irrelevant in the present context. The current definitions of some of these terms, as given in the Concise Oxford English Dictionary, are listed below:

| | | |
|---|---|---|
| *savage* | *• n 1* | *a member of a people regarded as primitive and uncivilized* |
| | *2* | *a brutal or vicious person* |
| *primitive* | *• adj 1* | *of, relating to, or denoting the earliest times in history or stages in evolution or development; of or denoting a preliterate, non-industrial society of simple organization* |
| | *2* | *offering an extremely basic level of comfort, convenience, or efficiency* |
| | *3* | *(of behaviour or emotion) instinctive and unreasoning* |
| *uncivilized* | *1* | *not socially or culturally advanced* |
| | *2* | *impolite; bad-mannered* |
| *native* | *1* | *a person born in a specified place or associated with a place by birth; a local inhabitant* |
| | *2* | *an animal or plant indigenous to a place* |
| | *3* | *(dated, chiefly offensive) a non-white original inhabitant of a country as regarded by European colonists or travellers* |
| *nomad* | | *a member of a people continually moving to find fresh pasture for its animals and having no permanent home; a wanderer* |
| *black* | *1* | *black colour or pigment...* |
| | *2* | *a member of a dark-skinned people, especially one of African or Australian Aboriginal ancestry* |

(Concise Oxford English Dictionary, 2006)

## Conventions

*Spelling:* this is generally shown as in the cited texts, even where, as sometimes occurs, a word may be mis-spelled in the original. An example is the variation in spelling of the earlier name for Tasmania, Van Diemen's Land, which occasionally appears as Van Dieman's Land.

*Italics:* these appear within the quotations only when they occur in original text, unless otherwise specified.

*References:* these are cited using the date of the first or original publication, where possible. Many of the early ethnographic accounts, for instance, have been published and reprinted more than once, often as facsimile reprints. Confusion as to the actual source can arise if one of these later printings is cited, and it can also give an inaccurate impression as to the antiquity of the source. This policy gives rise to some discrepancies between the dates used here and those conventionally assigned, and it also creates its own problems. The full journal of Joseph Banks, for example, was first published in the Beaglehole edition of 1962, but the publication cited in this work is the section dealing with the period spent along the eastern coastline of Australia in 1770, first published separately by Angus & Robertson and the State Library of New South Wales in 1998.

# PART ONE: BACKGROUND

## Chapter 1 Introduction

### The Tasmanian Paradox

In outlining his "Tasmanian Paradox", Rhys Jones attempted to explain the "problem" that, in his view, had become apparent from the ethnographic and archaeological records of Tasmania available at the time (Jones 1977a). In essence, the problem arose because the material culture of the Tasmanian Aborigines was comparatively simple. Not only did the ethnographic record suggest it was modest by Aboriginal standards, but the archaeological record suggested to Jones that their cultural repertoire had become diminished over time. In other words, its development appeared to have been moving in the wrong direction – in reverse, as it were. This was at odds with the trends on the Australian mainland. Indeed, the Tasmanian evidence was at odds with the widespread trend in many human societies towards more sophisticated technologies and more complex social and ecological relationships in the post-glacial world.

The paradox arose because ethnographic evidence indicated that the Tasmanian Aborigines were no less efficient or successful than their more technologically fashionable kin on the mainland. This in turn could raise questions, if not doubts, about prevailing assumptions as to the reasons for technological change in prehistory. Unless, that is, some special explanation could be found for why the Tasmanians might represent an exception to the rule.

The "serious questions" relate to models of technological and social change in prehistory, most of which are indebted, directly or indirectly, to assumptions derived from evolutionary analogies. These range from quasi-Darwinian ecological "adaptation" models to those based more on pre-Darwinian notions of innate "progress" in human society, though the latter are usually couched (and hence remain largely hidden) in an adaptationist vernacular. More generally, there is a "neo-Darwinian" amalgam of these, wherein ill-defined internal social forces (such as purported inherent tensions in social relations) constitute a convenient cultural analogue for genetic variation in biological evolution. These internal social forces provide a constant if stochastic impetus for change towards more varied and complex forms, which may or may not prove adaptive. Such evolution-based models could be challenged by the Tasmanian example. In his summary of the archaeological and ethnographic records of mainland Australia, Jones aimed to demonstrate how a strictly adaptationist approach raised more questions than it answered (ibid: 189-193). He went on to argue that social factors must have been the prime mover of cultural change in mainland Australia. This left him with the problem of why these factors should be absent, or attenuated, in Tasmania.

In attempting to resolve the paradox, Jones invoked physical and cultural isolation from the mainland, together with a low population level, as contributing factors in the alleged cultural decline. The cultural repertoire of the Tasmanian Aborigines, he suggested, had become impoverished, being effectively deprived of sufficient stimulation from interaction with a wider cultural sphere. Their cultural "gene pool", so to speak, had become too diminished to generate or sustain a healthy level of variation and innovation on its own. This led, more contentiously, to his proposition that their long-term prospects had become compromised by their isolation, even prior to European contact. Isolated as they were on a windswept island at the mercy of the Roaring Forties that swept in from the vast Southern Ocean, their minimalist approach to the bare essentials of life suggested to Jones not merely a "simplification in the tool kit" but "perhaps a squeezing of intellectuality", a culture in decline that was "doomed – doomed to a slow strangulation of the mind" (ibid: 202-203).

Subsequent archaeological discoveries in Tasmania were to highlight the Tasmanian "problem". These discoveries revealed the existence of numerous ice age occupation sites in the rugged southwest highlands of the island. Far from helping to resolve the paradox however, the discoveries have added another dimension. It emerged that Tasmanians in the late Pleistocene had successfully exploited the remote southwest region, an area so inhospitable to humans that it continues essentially uninhabited today, with most parts designated as wilderness areas or national parks. Moreover, they did so when local environmental conditions would have been more demanding. This was contrary to earlier predictions by Jones and others that the southwest in particular would have been uninhabitable during the late Pleistocene, and that any human presence in Tasmania would have been restricted to the milder coastal margins. Furthermore, the archaeological findings from these Pleistocene sites show that the Tasmanian Aborigines developed technologies and economic strategies that were at least as sophisticated as any on the Australian mainland at the time. In Jones' view, the Tasmanian innovations were even comparable in some respects to those of the "upper palaeolithic" cultures that became widespread in northern middle latitudes during the late Pleistocene. Among the Tasmanian innovations and changes can be mentioned bone tools, stone tools of more formal "scraper" typologies, targeted faunal hunting strategies, and parietal artworks in some of the caves. This archaeological evidence from the ice age tends to amplify Jones' paradox, hinting that the Tasmanian Aborigines at first European contact may have moved further in a seemingly retrograde direction than he had conjectured – or, at least, that they had reverted to a simpler or less specialised mode of existence.

### Another Tasmanian Paradox

While many elements of Jones' Tasmanian "paradox" can be criticised and discounted (e.g. Bowdler 1982: 41-44), there

may be another Tasmanian paradox. The problem relates specifically to clothing. Ethnographically, the Tasmanian Aborigines were virtually “naked”. The clothing paradox arises because it would appear, at first glance, that they should not have been. Among mainland Aborigines, habitual nakedness was also the rule, but clothing (of a simple, loosely-draped form) was used in some areas. Ethnographically, its distribution appeared to correspond broadly to basic human thermal requirements. Aborigines in the cooler southern parts of the continent often wore capes of kangaroo skins and long cloaks sewn from opossum furs, especially in the winter months.

One complication is that these garments (along with other items which may or may not qualify as clothing) could have been used by Aborigines on the southern mainland for other than thermal reasons, at least on occasions. For instance there are some early descriptions of long cloaks or robes being worn in the Port Phillip area by “chiefs”, presumably as symbols of their higher status. This might add credence to claims of more “complex” social and economic relationships developing in some parts of Aboriginal Australia during the Holocene. In this case, any discrepancy between the extent of clothing use between the southern mainland and Tasmanian Aborigines could reflect differences in cultural development. However, the interpretation of this ethnographic evidence as suggesting the emergence of more complex functions for clothing on the mainland is problematical for a number of reasons, as discussed later. In any case, it is clear from the ethnographic record that the use of clothing by Aborigines on the mainland was predominantly if not exclusively related to thermal conditions, with its geographical distribution corresponding very closely with increasing exposure to colder conditions in the southern parts of the continent (Mountford 1963, Wright 1979).

In Tasmania, where lower air temperatures are exacerbated by a pronounced wind chill effect, the inhabitants would be expected to avail themselves of at least as much thermal protection as did their counterparts across Bass Strait. Yet the Tasmanian Aborigines may not conform to this expectation. Many early European visitors to the island remarked, some-times with a tone verging on bewilderment, that the inhabitants were either completely naked in the cold, or else seemed to use their skimpy wallaby skins for holding their infants, or for carrying implements or other items on their backs, rather than to fend off the cold. Likewise, their use of artificial shelter in the form of wind-breaks was distinctly minimal and casual. Among the Tasmanians, physical protection from the elements appeared hardly adequate, even inadequate.

As with Jones’ paradox, the ice age occupation of Tasmania only adds to the clothing paradox. Markedly colder conditions during the late Pleistocene meant a heightened need for thermal protection in the form of clothing and shelter. Palaeoenvironmental data point to colder and windier conditions that would have jeopardised if not precluded human survival without such additional protection. As discussed later, there is indeed some indirect archaeological evidence suggesting that the Aboriginal inhabitants did in fact avail themselves of such protective measures. So the Tasmanian Aborigines of the “ethnographic present” may not only have used less thermal protection than did their mainland contemporaries, they may have used less than their own predecessors in the region.

In other words, the ice age evidence intimates that the Tasmanian Aborigines reduced their use of clothing in the post-glacial period. This might not represent an interpretive problem, were it not for the fact that their use of clothing was so minimal, being virtually non-existent. Their counterparts on the adjacent southern mainland, for instance, evidently still needed to use some clothing to keep warm. Thermal conditions in Tasmania at the time of European contact were such that frequent if not regular use of clothing might be expected for physiological reasons alone. Furthermore, their forebears in the ice age presumably became familiar with its use, and acquired the requisite technologies. A reduction in clothing makes sense in warmer Holocene environments, yet the problem remains that there appears to have been greater use of clothing in other, warmer regions, including parts of mainland Australia. Moreover, in many parts of the world, clothing became associated with a range of non-thermal functions, at both a personal or psychological level and at a social level (with these being interrelated). Also, it underwent a series of further technological developments, most notably with the spread of textile production. None of these trends are seen among the Tasmanian Aborigines at the time of European contact. This occurred despite their exposure to colder conditions during the late Pleistocene, which should have given them a lead with regard to clothing technologies compared to the mainland Aborigines.

The Tasmanian clothing paradox can be approached by first presenting a critical analysis of the ethnographic record, to confirm the existence and establish the extent of the paradox. The archaeological record can also be examined to ascertain to what extent it yields evidence of behavioural responses among Tasmanian Aborigines to changing thermal conditions during the late Pleistocene. The findings can then be analysed by utilising data from a range of relevant disciplines including thermal physiology, palaeoenvironmental sciences, and physical anthropology as it relates to thermal adaptations. It is anticipated that the clothing paradox may be usefully explored and possibly resolved in this manner, and that its resolution will have wider ramifications. As Jones himself intimated (and reiterated with added emphasis after the Pleistocene evidence emerged), the Tasmanian issues bear upon wider theoretical questions relating to human technological and other developments on a global scale in the late Quaternary.

## Relevant Issues

In addressing the Tasmanian clothing paradox and its ramifications – both ethnographic and archaeological – a

number of separate strands of evidence need to be disentangled. These strands, and their relation to the paradox, comprise:

*ethnography*: the use of clothing and other forms of thermal insulation among Tasmanian and mainland Aboriginal populations, and the interpretation of any regional differences;

*archaeology*: the Pleistocene and Holocene records in relation to technological and other behavioural changes that may relate to thermal contingencies, especially with regard to the use of clothing and shelter;

*environment*: meteorological data for the historical period, and palaeoenvironmental data for the Pleistocene and Holocene, that bear upon human thermal requirements and predictable human responses to thermal conditions;

*morphology*: evidence for thermal adaptations among mainland and Tasmanian Aboriginal populations, and how these can affect interpretation of morphological variation as well as influence cultural "adaptations", particularly use of clothing; and:

*physiology*: thermal issues for humans and the physiology of clothing, in relation to prehistoric behavioural adjustments and technological developments in general, and particularly in the Australian (including Tasmanian) Aboriginal context.

**Ethnography**

The ethnographic record in this case consists of the historical accounts by European visitors in the period prior to white settlement, along with the early historical records of settlers and explorers, especially in the first few decades of the colonial era. These can be examined for descriptions of the use of clothing and shelter by Aborigines, both in Tasmania and on the Australian mainland. Also, the records can be examined for descriptions of the physical appearance of the Aboriginal inhabitants, in terms of morphological variation that may be relevant to their thermal requirements. This material constitutes the primary source of evidence bearing upon the Tasmanian clothing paradox, and will be utilised for assembling a data base in the main analysis, the "ethnographic" study.

First, the available written records are to be surveyed for first-hand observations that relate to these features. The raw data from the survey are presented in the first Appendix, A1, in chronological order. The survey focuses on evidence for regional variation with respect to thermal environmental adaptations among the Aboriginal population, particularly evidence that may have a bearing on the Tasmanian clothing paradox. Some of the personal reactions and interpretations made by the European observers at the time are also presented. The survey is divided into four sections; the first two are the observations on the Tasmanian Aborigines, both prior to and following European settlement, followed by two sections containing observations relating to the mainland Aborigines, again both prior to and following European settlement. In each section, ethnographic records are selected as they relate to three observable features, viz. use of clothing, use of shelter, and descriptions of Aboriginal morphology. The latter for example will include any references in the literature to the linearity or stockiness of body form, and to other morphological features having possible thermal significance, such as limb proportions and body hair.

These data are then assembled in tabulated form, which can facilitate a transformation of the subjective first-hand descriptions into more objective categories. For instance, reports of the Aborigines in a specific encounter may include descriptors such as "entirely naked" on the one hand, or may instead contain reference to marsupial-skin garments being worn by some or all of the Aborigines on that particular occasion. For present purposes, the former instance may be categorised as "naked" or "unclothed", while the latter may be categorised as "clothed". In some cases, however, there will be a degree of ambiguity in the descriptions. As a consequence, the categorisation procedure inevitably introduces a potential source of error, but it is nonetheless a necessary step in embarking upon any large-scale analysis of the ethnographic data. These methodological issues and limitations are reviewed in due course, and need to be taken into account when drawing any conclusions from the ethnographic study. Once categorised, the first-hand observations can be subjected to quantitative analyses to assess to what extent any emergent trends in the data conform to, or appear to diverge from, thermal principles. In particular, the evidence for disconformity with respect to the Tasmanian Aborigines can be examined and critically evaluated. The results of these analyses can then be discussed in relation to thermal principles. The latter consist of the findings from thermal physiological studies of modern humans in terms of minimum thermal requirements, acclimatisation, and adaptations (biological and behavioural) in differing thermal environments.

**Archaeology**

Just as the ethnography of the Tasmanian Aborigines presents challenges for explanatory models of human cultural variation, the archaeology of Tasmania has proved challenging for a number of theoretical models. Summaries of the Tasmanian data and the issues appear in Jones (1995), Allen (1996) and Cosgrove (1999), which also provide detailed bibliographies. In Jones' opinion, the Holocene record hints at a distinct disinterest on the part of the Tasmanian Aborigines in any general post-glacial trend towards complexity. Those who searched for signs of economic intensification in Holocene Tasmania, for instance in the southeast of the island (e.g. Lourandos 1985: 397-413), have since turned their attention elsewhere. Yet the Pleistocene record shows that the Tasmanians were capable of change and innovation if it suited them. This is evident in the Pleistocene archaeological record of the inland southwest, which challenged Bowdler's coastal colonisation

model for the Australian continent (Bowdler 1977: 213-219, 234). Each of these archaeological difficulties can be approached by examining thermal issues. This requires an appreciation of how the changing late Quaternary environments in the region resulted in changing thermal contingencies and how these in turn may have affected behavioural options for humans, and how such influences may be discernible in the Tasmanian archaeological record.

In relation to the clothing paradox, a thermal analysis of the Tasmanian archaeological record will be a useful adjunct to the ethnographic study. During the late Pleistocene, human requirements for thermal protection, especially in the form of shelter and clothing, would have increased, possibly to the point of becoming critical for survival. If so, this may prove useful in formulating any explanatory scheme for the otherwise unexpected human presence in the southwest, and also in relation to certain aspects of the technological innovations that are witnessed in the region. Specifically, evidence for technologies that may be related to the manufacture of more thermally-effective clothing needs to be carefully assessed. If, as Jones and others have suggested, there is indeed some evidence for an elaboration of clothing technologies and an intensified responsiveness to thermal parameters, this raises the question of whether there was a subsequent diminution of these adaptations in the post-glacial period. More pertinent is the question of why any such diminution should have proceeded so far in Tasmania, to the extent that the Tasmanian Aborigines could manage with less clothing than Aborigines on the mainland – if, as the ethnographic study aims to determine, the clothing paradox is indeed a real phenomenon.

Certain features of the Tasmanian archaeological record are amenable to analysis in relation to human thermal parameters, and these can be categorised into three classes of data, namely site type, technology, and fauna.

The first category, *site type*, is the focus of the archaeological case study. This examines minimum temperature and wind-chill conditions in Tasmania during the late Pleistocene and their influence on human shelter needs. Whether the southwest region, with its cave-bearing karst formations offering natural shelter, was utilised on a seasonal basis is unclear. If so, there is evidence suggesting that occupation of these higher-altitude locations occurred in the colder months. Such a pattern is at odds with earlier expectations that any human presence would have been strictly coastal, especially in the colder months. It is also at variance with the observed seasonal movements of Tasmanian Aborigines at the time of European contact, when coastal areas were favoured during the winter months. Protection from wind chill may emerge as a crucial factor in this instance, in terms of making winter occupation of the region a preferred option. One specific issue relates to evidence regarding the aspect of utilised cave sites in relation to prevailing wind direction. If so, it would add further weight to the suggestion that the Tasmanian Aborigines were indeed subject to more critical thermal conditions during the late Pleistocene, and this may prove relevant to the clothing paradox, as discussed later.

The *technology* category includes two of the major trends in the Pleistocene archaeological record of Tasmania. One is the appearance of tools in the form of points made from marsupial limb bones, a tool form which later disappears from the Tasmanian archaeological record in the mid-Holocene. The second is the increasing occurrence of diminutive reworked stone tools, the most distinctive of which have been termed “thumbnail scrapers”. A detailed examination of these technological trends in relation to thermal and particularly clothing requirements is beyond the scope of this work, but they will be reviewed later in the light of the results obtained in the cave site study.

The *fauna* category will highlight evidence for the “targeted” hunting of certain animal species, primarily the red-necked or Bennett's wallaby. It examines the extent to which this may reflect increased thermal demands for raw materials needed to manufacture adequate clothing, as well as increased caloric requirements for humans in these periglacial environments. Faunal studies have hinted at other aspects of human behaviour which could be related to thermal contingencies, including the skinning of animals for their pelts, and the extraction of high-calorie bone marrow and brain tissue. Again, while this issue cannot be examined in depth in this thesis, it will be discussed in the light of the other findings.

A thermal analysis of the Tasmanian archaeological record raises interpretive issues for Australian prehistory, and also for prehistoric archaeology in general. It has particular relevance to the intercontinental comparisons of human behaviour and technological innovation that were seen as being of such potential value when the Pleistocene sites were discovered (e.g. Kiernan *et al.* 1983: 31, Jones 1987: 44). The Tasmanian findings serve as a test case, as it were, for general theories of human technological and cultural development. Most of the latter have been formulated with a predominant emphasis on the northern hemisphere. Jones makes reference in a general sense to thermal considerations, especially the human need for clothing and shelter in the colder conditions. While it is true that both regions lie at a similar distance from the equator, and both witnessed glaciers during the last ice age, the effective thermal conditions for humans were no more equivalent than were the fauna. It is the differences as well as the similarities that are significant from a thermal perspective in relation to large-scale trends in human behavioural responses and technological developments. These differences are also significant in relation to the strikingly dissimilar technological and cultural trajectories taken by humans in the two regions after the ice age came to end. The coincidence between these trends and major environmental change during and after the ice age has always been evident, although its interpretation presents challenges (e.g. Cosgrove 1995a: 99-100). Part of the problem, it is argued here, is that insufficient attention has been given to the direct impact on humans of the major

environmental parameter which, after all, ultimately defines the Pleistocene, namely a substantial and sustained lowering of mean temperatures on a global scale.

The archaeological case study will look at one aspect of these issues, the thermal physiological significance of wind-chill during the late Pleistocene in Tasmania and its relevance to the human use of shelter in these environments as manifested in the archaeological record. The results of this analysis will then be used to pursue some of the other likely thermal patterns in the archaeological record, particularly the technological developments that may relate, at least in part, to the use of clothing. Both of these behaviours, the use of shelter and clothing, will be viewed in this instance as primarily thermal responses to the changing environments.

**Environment**

Thermal aspects of Tasmanian environments – past and present – include temperature ranges (especially minimums), wind velocities (especially maximums) and, to a lesser extent, moisture (humidity and precipitation). Meteorological records covering the historical period will have a major bearing on the interpretation of the ethnographic evidence for clothing use, primarily in establishing the level of cold tolerance among the Tasmanian Aborigines. Comparable meteorological data from the mainland need to be included, since some of these environments inhabited by mainland Aborigines may prove almost as challenging as those of Tasmania in terms of physiological requirements and limitations for naked humans.

The past thermal environments of Tasmania can be divided into late Pleistocene (from around 35,000 years ago, when there are the earliest indications of a human presence in the region, up to the end of the last ice age around 12,000 years ago), and Holocene (the post-glacial period, from 12,000 years ago to the present). Of special concern in this context are palaeoenvironmental data that can provide estimates of mean and minimum temperature trends, and also average wind velocities. For the Pleistocene it is the timing, magnitude and duration of the temperature depression in the Last Glacial Maximum (LGM), dated conventionally to around 20,000 years ago, that is of most interest. Palaeoenvironmental evidence suggesting a "long LGM" beginning around 28-30,000 years ago will be considered in some detail.

Aside from the colder temperatures, there is evidence for windier and drier conditions that will be reviewed in relation not only to human physiology but also to changes in vegetation cover. The latter has thermal implications for humans, including its impact on exposure to wind chill and the availability of raw materials for the construction of artificial shelters. Vegetation also affects fauna, which in turn is relevant for the increased human caloric requirements in cold environments, and also the availability of raw materials for manufacturing garments.

The Holocene palaeoenvironmental record has a number of points of interest. First is the timing and magnitude of the post-glacial "climatic optimum", when average temperatures may have been somewhat higher than at present. Aside from its obvious bearing on the question of any reduction in clothing use by the Tasmanian Aborigines, it has been an ongoing focus of archaeological attention, along with the post-LGM warming trend, in terms of the expansion of dense rainforest vegetation and the abandonment of Pleistocene occupation sites in the southwest.

Another aspect of the palaeoenvironmental record is sea-level data which, aside from providing a proxy measure of mean temperature levels, determine a minimum duration for geophysical isolation of Tasmanian Aborigines from those on the mainland. Isolation of the Tasmanians has a number of important ramifications, even leaving aside Jones' invocation of this factor in his formulation of his "Tasmanian Paradox". Most attention has centred on dating the opening and the severing of dry land connections to the mainland. However, there are other features of the palaeoenvironments which may have resulted in effective thermal or "physiological" isolation of humans in the Tasmanian region throughout much of the late Pleistocene, especially if the LGM was more prolonged than previously thought.

**Morphology**

Most of the physical anthropological research concerning variation in the bodily form and other physical features of the Aborigines has been focussed on the question of whether or not it provides evidence in favour of multiple origins, with the Tasmanian Aborigines figuring prominently in this debate. The use of statistical analyses, especially of metrical craniological data, suggests that the variation is no more (and perhaps even less) than should be expected, given the duration and geographical range of Aboriginal occupation of the continent, and allowing also for the subsequent isolation of a smaller group in Tasmania (Pardoe 1991: 10-12).

Still, variation does exist and, as proponents of the multiple origins model have emphasised, the variation is not random but shows distinct regional trends or patterning (Birdsell 1993). Most striking is an overall north-south or latitudinal gradient for many of the features studied, both cranial and post-cranial, with a secondary gradient extending diagonally from the northwest to the southeast. There is also a third, more discontinuous element in the morphological data, consisting primarily of the Tasmanians and to a lesser extent a small group in the rainforests of the northeast who manifested a number of discrete attributes.

In other words, there exists overall homogeneity of the Australian Aboriginal population on the one hand, and regional variation within that population on the other. As outlined later, it may be possible to reconcile this apparent discrepancy without recourse to special explanations (such as multiple origins). Moreover, it is possible to do so in a manner which highlights the likely influence of thermal en-

vironments. Most of the documented morphological variation among mainland and Tasmanian Aborigines may conform to similar regional trends in human morphology seen on other continents. Such trends have been interpreted in physical anthropology as reflecting the influence of known principles of thermal adaptations in morphology. The available meteorological and palaeoenvironmental data can be used to ascertain the past and present thermal environments and how these conditions varied within the region. Certain trends are predictable on thermal grounds alone, and it may be the case that these can be shown to account much of the morphological evidence for Aboriginal heterogeneity. Any thermally-adaptive trends in morphology will interact with known principles of thermal physiology to influence human requirements for additional adaptations, notably behavioural responses in the form of clothing and shelter.

It is this last aspect which could prove pivotal for the Tasmanian clothing paradox. There may be evidence for the development of morphological cold adaptations among Australian Aborigines, especially among those in southern regions who experienced the more extreme thermal conditions associated with the LGM. This would have a bearing on the ability of Aborigines in these regions, particularly in Tasmania, to manage without much clothing in the post-glacial period. Morphological variation is therefore one area that must be considered in some detail. For this reason, a morphological study of Australian Aborigines has been undertaken, and the results are presented following those of the ethnographic study.

The main data base for the morphological study comprises an extensive data set provided in Birdsell (1993), in combination with meteorological data made available by the Australian Bureau of Meteorology. These data are subjected to a series of statistical analyses to assess the evidence for morphological thermal adaptations in the Australian Aboriginal population. Much of Birdsell's data, unfortunately, do not include Tasmanian Aborigines, although it may be feasible to make some inferences based on the mainland trends. In addition to Birdsell's data, there exist limited osteological data for Tasmanian Aborigines, and some of these data (such as limb proportions) will be utilised to assess the extent of thermal morphological adaptations among Tasmanians, by comparing results with those based on osteological data from mainland Aboriginal populations.

**Physiology**

Linking together all of these aspects of the Tasmanian clothing paradox – ethnographic, archaeological, environmental and morphological – is the science of human thermal physiology. Among the more pertinent principles of thermal physiology – indeed of sensory physiology in general – is habituation, in this instance to cold. Thermal conditions in Tasmania, and on the southern mainland of Australia, were often too cold for Europeans to manage without substantial amounts of what is herein classed as "complex" clothing – that is, more than one layer of properly fitted garments, as outlined below. The Aborigines, in contrast, were generally able to remain reasonably comfortable without this type of clothing. The ethnographic evidence shows that along with their use of fire and basic forms of natural or artificial shelter, they needed only to avail themselves of the most rudimentary protection in the form of loosely draped, single layer garments (herein termed "simple" clothing), and this only when air temperatures and wind chill exceeded their physiological capacity for cold tolerance. To the early European observers, who were ignorant of the physiological principle of habituation and so assumed an equivalent experience of temperatures on the part of the Aborigines, the latter's failure to utilise comparable clothing was one of the most self-evident indications of their perceived cultural insufficiency (e.g. Roux 1992: 42-43).

No physiological studies were made of the Tasmanian Aborigines, but the enhanced cold tolerance of mainland Aborigines has been researched, and the findings will be reviewed in some detail. In brief, the research has documented not only a significant level of cold tolerance among habitually unclothed Aborigines who lived in the central deserts of the mainland, but also a number of other physiological defence mechanisms that allowed them to endure mild sub-zero nocturnal temperatures without any clothing or discomfort at all. However, even these acclimatised Aborigines needed to make use of campfires and rudimentary windbreaks. The ethnographic record shows that those in the cooler southern regions (including Tasmania) also needed to take additional measures such as applying oils or grease to their bodies to help defeat wind-chill, or wearing loose capes or longer cloaks when conditions demanded. Far from implying that habitually-naked humans who are regularly exposed to cold are not subject to physiological limits or that any such limits are difficult to define, the ethnographic and physiological evidence from Australian Aborigines shows unambiguously that there are definable limits to human cold tolerance. Beyond these limits, even fully-acclimatised, routinely-naked peoples will either need to move to warmer climes, seek shelter and consider using clothes, or face the risks of cold stress and hypothermia. Yet in prehistoric archaeology, there has been a tendency to discount temperature as a significant factor in human responses to environmental change. For instance, thermal factors in the human occupation of Cave Bay Cave around 23,000 years ago and its apparent abandonment 18,000 years ago were dismissed by Bowdler. She suggested that the "simple" factor of lower temperatures at the LGM was unlikely to be significant, if only because Tasmanian Aborigines in the late Holocene were able to exploit subalpine environments without being greatly hindered by low temperatures. This lead her to assert that "judgments about temperature tolerances should be made with caution, if at all" (Bowdler 1984: 130).

Another principle of human thermal physiology, and of particular significance for both the Tasmanian Aborigines of

the “ethnographic present” and for the prehistoric archaeology of their late Pleistocene forebears, relates to the wind-chill effect. This is a major determinant of hypothermia risks and survival times for exposed humans. The contemporary Tasmanian climate is marked not only by its low mean and minimum temperatures (by Australian standards) and its high rainfall, but also by the relatively high frequency of strong winds. These can render it more challenging thermally than other regions that experience similar temperatures – for instance nearby areas on the southern mainland, some of which at higher elevations have lower mean winter air temperatures than any parts of Tasmania. Wind-chill will only compound the Tasmanian clothing paradox, if it emerges from the analysis of the ethnographic evidence that there was indeed less use of clothing in Tasmania compared, for example, to the Port Phillip area across Bass Strait (e.g. Tuckey 1805: 178).

Evidence for stronger winds in late Pleistocene Tasmania may be significant in relation to the archaeological record, for more than one reason. First, it means that Aborigines in the region at the time may have needed to wear more substantial clothing, and to use it on a more regular basis. Indications of this can be sought in the archaeological record – if, as intimated above, prehistoric clothing is not always as archaeologically “invisible” as is generally assumed. Second, the wind-chill effect means that shelter becomes a more critical issue for humans, with or without clothing. In the case of Tasmania, this bears upon a number of outstanding archaeological problems. These issues will be addressed later in the archaeological section of the present study.

# Chapter 2 First Impressions

A narrative review provides information that can be lost in a quantitative approach. This information includes historical context and the subjective reactions of the European observers. In the latter's cultural milieu, the use of clothing was strongly sanctioned. It carried ethical and moral connotations, associated with preconceptions as to the minimal cultural attributes of any decent or "civilised" human society. As such, the use of clothing was one feature employed in formulating ostensibly objective or "scientific" assessments of the Aboriginal people and their societies.

These subjective elements in the Europeans' perceptions might be deemed matters of historical curiosity, but much of the ethnographic data is imbued with these elements. As a result, the descriptions in relation to clothing are often couched in demeaning or overtly derogative tones. Unfortunately, it is not always possible to remove or edit these elements without removing or damaging the data itself. Aside from a sense of moral insufficiency associated with a perceived insufficiency of clothing, there was often also a sense of pragmatic insufficiency in the Aborigines' relative lack of protection from cold. Being largely ignorant of the role of physiological habituation and its effect on the perception of temperatures, Europeans often assessed the Aborigines as demonstrating a level of protection that was manifestly inadequate for human health or comfort. This is apparent in first-hand descriptions not only of their clothing but also their use of shelter.

## Tasmania

### Clothing

The first European expedition arrived in Tasmania in December 1642, lead by Abel Tasman. No Aborigines were observed, but smoke was seen rising from numerous fires. In the nearby forests, some of his men reported hearing human voices, and Tasman suspected the local inhabitants had closely "scrutinised" the visitors (Tasman 1992:13-15). It was to be another 130 years before the Aborigines were seen by Europeans. This occurred when Marion du Fresne visited in March 1772. Marion was evidently concerned about first impressions and, influenced by Rousseau's vision of "noble savagery", he arranged for some crew members to strip naked. They "emerged from the surf as "natural" men, bearing trinkets and enlightenment for the naked islanders" (Mulvaney 1989: 29). The journal of Crozet documents this first encounter, and he described the appearance of the Tasmanian Aborigines as follows:

> *The men as well as the women were of ordinary height, black, with woolly hair, and men and women were all equally naked. Some of the women carried their children on their backs, fastened by a rush cord*
> (Roth 1891: 18)

What especially made an impression on the visitors was that exposure to temperatures perceived as distinctly cold by the Europeans had not induced the Tasmanian Aborigines to use any clothing on a regular basis:

> *The climate of this southern part of New Holland seemed very cold to us, although we were there at the end of summer; we could not understand how the savages could exist there in their naked state*
> (Roth 1891: 21)

Furneaux followed in 1773 but, like Tasman, he failed to meet any of the Aborigines. A second encounter took place when Cook arrived in January 1777, during his third Pacific voyage. Cook described the Tasmanians as "quite naked" (Cook 1784: 96). Lieutenant King however reported women wearing "kangooroo" skins over their shoulders, which he thought were used more to carry their infants than for warmth or to "cover those parts which most nations conceal"; the women were otherwise "as naked as the men" (King, ibid: 101). The surgeon Anderson compared them to the people of Tierra del Fuego, at latitude 54°S in South America, whose limited use of clothes had been documented on Cook's first Pacific voyage in 1769 (Parkinson 1784: 6-10). Anderson noted they had "not invention sufficient to make clothing for defending themselves from the rigour of their climate, though furnished with the materials" (Anderson, in Cook 1784: 112). Such remarks illustrate how lack of clothing could be cited as evidence of restricted cultural capacity – a theme echoed in some later assessments based on archaeological evidence.

Next to visit was Bligh on the *Bounty.* He had visited with Cook in 1777, and in the journal from his second visit he describes the Tasmanians as "perfectly naked" (Bligh 1792: 51). Then followed the *Mercury* in July 1789, commanded by Cox. The journal of Mortimer reiterates Cook's impression that the women did not necessarily use the capes for reasons of warmth:

> *They were entirely naked, except one man, who had a necklace of small shells, and some of the women who had a kind of cloak or bag thrown over their shoulders; in which, I suppose, they carry their children, and what few moveables they possess*
> (Mortimer 1791: 19)

Bligh returned again in February 1792. His men caught only a fleeting glimpse of the Aborigines on this occasion, with Lieutenant Tobin reporting men and women with capes on their shoulders:

> *...it did not appear that either sex was quite naked, the skin of an animal being thrown over the shoulders, but seemingly more to protect them from the weather than from any sense of decency*
> (Tobin, in Mackaness 1943: 33)

LaBillardière, naturalist on the d'Entrecasteaux expedition, visited late in the summer of 1773. He found it "very astonishing" that, while the Europeans "experienced the cold at

night to be pretty severe, these people did not feel the necessity of clothing themselves" (LaBillardière 1800: 296). Later, describing the short marsupial capes worn at times by some of them, he noted that "by a very strange oddity, this kind of clothing serves only to cover the shoulders" (LaBillardière 1803, in Duyker 2003: 111). From a physiological perspective, covering the upper body may provide sufficient protection among people having a more "stocky" body build, with relatively broad shoulders, as discussed later. Yet there is a hint of prudishness in LaBillardière's remark. The use of clothing to cover part of the body might be acceptable, but the upper part was the "wrong" part, as it were. It left the lower parts, including genitalia, exposed. It is as though the Tasmanian Aborigines were ignorant of some universal "law" stipulating that if only a part of the human body is covered, it should be the lower part, for reasons of decency.

Two months after the departure of D'Entrecasteaux, Hayes arrived and remained more than six weeks, anchoring in various locations along the eastern coast of Tasmania. It would seem likely that he encountered the local inhabitants but, to the great loss of ethnography, no journal records of his visit survive (Lee 1912: 16-45).

The question of whether Tasmania was joined to the Australian mainland was finally settled when Bass and Flinders circumnavigated the island between October 1798 and January 1799. They had little contact with the inhabitants, but in the vicinity of Port Dalrymple on the northern coast they saw three Aborigines from a distance – a man, a woman and a male child. Like Tobin on Bligh's 1792 visit, both sexes were reported as wearing "something wrapped round them which resembled cloaks of skins" (Flinders 1814: clv). Bass and Flinders also observed the inhabitants when exploring the Derwent River in the southeast of the island, surprising a small group consisting of two women and a man. The women were glimpsed only briefly as they disappeared among the trees, but they appeared to each have "a short covering hanging loose from their shoulders"(Collins 1802: 134).

The decade between Bass and Flinders' circumnavigation and the first English settlement in 1803 saw one more European voyage to Tasmania, the French expedition led by Baudin. The scientific intentions of the Baudin expedition were spelt out in recommendations made by the newly-formed *Société des Observateurs de l'Homme*. The *Société* issued Baudin with advice regarding the proper recording of observations, as set out by Joseph-Marie Dégerando. With respect to clothing, Dégerando bemoaned the fact that remarks about clothing, or the lack thereof, were typically cursory and of limited use for scientific purposes (Dégerando 1969: 79-80).

The *Géographe* and *Naturaliste* spent some six weeks in the summer of 1802 at anchor in the environs of Bruny and Maria Islands, during which there was ample opportunity to observe the inhabitants at close quarters. Baudin summarised his impressions of their use of clothing as follows:

> *Although we saw some with their shoulders and chest covered by a kangaroo skin, the men are more generally naked. However, all the women that we saw wore skins. These seemed to be intended principally to form a sort of bag, in which they place what they are given or what they gather when out walking*
>
> (Baudin 1974: 344)

In adhering to Dégerando's prescriptions, the naturalist François Péron prepared detailed observations of the Tasmanian Aborigines. He had begun the voyage inspired by Rousseau's reflections on the "naked savage" being more "noble" than "savage". Yet his summation of the Tasmanian Aborigines repudiates Rousseau, with a shift in emphasis to their perceived deficiencies, framed in a plausibly objective list of attributes that presages later classificatory schemes:

> *...without any regular chiefs, without laws, or any form of government, destitute of every form of art, having no idea of agriculture, of the use of metals, or animals; without clothing or fixed habitations, or any other retreat than a miserable pent-house of bark, to protect him against the south winds... the inhabitant of these regions... is, in every sense of the word,* the child of nature
>
> (Péron 1809: 313, emphasis original)

Péron's anthropology foreshadows evolutionary models that were to supersede French libertarian values, and which subsequently became entrenched in the anthropological tradition. A subversive threat posed by Rousseau's "noble savage" was replaced by implicit ideals that better accommodated the values of "civilised" society. This meant devaluing a lifestyle that was distinctly alternative, discernible here in the depiction of the Tasmanian Aboriginal as a "child of nature", with its developmental overtones and demeaning undertones. Left behind on their remote island as the rest of humanity had matured, they were given trinkets and were to be clothed and educated and taught how to develop social hierarchies and farming. Quaint though these may appear, the presumptions underlying this ethnographic picture have informed anthropological thinking, with the Tasmanian Aborigines becoming "representatives of palaeolithic man" (Tylor 1894: 148-152). These presumptions have continued to resurface, as with Jones' Tasmanian paradox, in which the "problem" of the Tasmanian Aborigines only exists because human societies are supposed to develop, or evolve, or adapt, or do almost anything other than simply exist.

**Shelter**

Similar issues arise with the Tasmanian Aborigines' use of shelter, minus the moral connotations associated with clothing. Like the latter, their use of shelter was not only less than what was expected of any self-respecting human culture, it appeared to be less than the minimum required for physical protection. Again this led to negative assessments of their cultural capacity. Condescending reactions served to reinforce a paternalistic response, which was not without

political ramifications. A lack of decent dwellings was exploited by the colonial administration as a rationale for appropriating territory used on a seasonal or irregular basis by the Aborigines, with their lack of permanent habitations taken to signify a lack of occupation or ownership of the land.

Throughout the journal reports of the first European visitors, accounts of the Tasmanians' transient artificial shelters are adorned with pejorative descriptions such as "miserable" (Bligh 1792: 52), of "bad construction" (Bass and Flinders, in Collins 1802: 135), and "the most miserable things imaginable" (Baudin 1974: 345). Indeed it was the rudimentary nature of their shelter in the "very cold" climate that had surprised Crozet as much as the want of clothes:

> *What appeared more extraordinary to us was that we found no indication of houses, only some break-winds, rudely formed of branches of trees, with traces of fire...*
>
> (Roth 1891: 21)

As with clothing, the inference is that their use of shelter not only represents evidence of cultural inadequacy, but the level of protection afforded was almost insufficient as physical protection from the elements, particularly from the cold winds and the chilling effects of the rain:

> *Near the beach, and close to the stream of water, we found a small hut, or rather hovel, of a circular form, open at the top, and rudely constructed of branches of trees, and dried leaves, so as barely to afford a shelter from the inclemency of the weather*
>
> (Mortimer 1791: 15)

And, in a similar vein, is the following from Collins' summary of Bass and Flinders' reports:

> *Their huts, of which seven or eight were frequently found together like a little encampment, were constructed of bark torn in long stripes from some neighbouring tree... But, after all their labour, they have not ingenuity sufficient to place the strips of bark in such as manner as to preclude the free admission of the rain. It is somewhat strange, that in the latitude of 41°, want should not have sharpened their ideas to the invention of some more convenient habitation...*
>
> (Collins 1802: 121-122)

There is a hint in some of these reports that the seeming physiological insufficiency of their use of shelter reflected an inadequacy of cultural capacity or adaptability, presaging Jones' "strangulation of the mind" scenario in his depiction of the Tasmanian archaeological paradox. Their simple wind-breaks and huts were "constructed with very little ability" (D'Entrecasteaux 2001: 34), this being "proof of their lack of ingenuity" (Roux 1992: 42). Although Furneaux failed to meet any of the Tasmanian Aborigines during his visit in 1773, he came across some of their shelters and these led him to form a pessimistic impression of those who made them:

> *...there were several wigwams or huts... so poorly done that they will hardly keep out a shower of rain... being altogether, from what we could judge, a very ignorant and wretched set of people...*
>
> (Furneaux, in Cook 1777: 113-114)

Evidence from human thermal physiology and climatic records may help in forming a less bleak assessment of the Tasmanian Aborigines, with their use of cultural innovations as protection from the elements constituting neither more nor less than what was required. There is an indication, for instance, of substantial forms of shelter in the more inclement environments of the midlands and along the western coast (Plomley 1966: 139). In 1827 Jorgensen, in the vicinity of Mount Norfolk, came across huts of more weatherproof construction than those on the less exposed eastern coast. He described one such hut:

> *In passing along they observed a very neat and compact native hut. It bore all the marks of the simple rudiments of Gothic architecture; it rose in the shape of an oblong dome, and might easily contain from 16 to 20 persons. The wood used for the principle supporters was bent in a curve, and seemed to have been rendered hard by fire. It was uncommonly neatly thatched, and the doorway was about two and a half feet high. Necessity is the mother of invention, and therefore the Aborigines on this coast have been compelled to construct compact huts to screen them from the inclemency of the cold, and the boisterous winds, especially where fuel is so scarce as it is here*
>
> (Jorgensen 1829: 48-49)

Similarly Robinson, at Nye Bay on the southwest coast in 1830 during one of his missions to contact all the remaining tribes, came across numerous huts:

> *A large hut was erected there, about ten by ten and seven feet in height. This hut, like many others that I saw, was in the form of a circular dome and was stuck full of duck or cockatoo feathers. The door or entrance was a small hole about a foot wide by two feet high*
>
> (Plomley 1966: 139)

Shelter provides another source of ethnographic evidence as to thermal requirements, and to the behavioural and technological responses of the Tasmanian Aborigines, in addition to their use of clothing. It has relevance also to the late Pleistocene archaeological record in Tasmania, in terms of thermal parameters and minimum shelter requirements. Later, in the prehistory study (Chapters 9 and 10), these factors are examined in relation to human occupation of cave sites in southwest Tasmania during the more challenging environmental conditions that prevailed during the glacial maximum.

## Mainland

### Clothing

While the first known European landfalls on the mainland occurred around Cape York and the Gulf of Carpentaria in northern Australia in 1606, the earliest surviving account of contact with the Aborigines is that of Carstensz in 1623, on the western coast of the Gulf near Arnhem Land (latitude 13˚S). Carstensz described the inhabitants as "stark naked", and he also reported finding "small huts made of dry hay" (Heeres 1899: 36-37). Pelsaert, whose ship the *Batavia* was wrecked in the vicinity of North-West Cape in 1629, encountered up to a dozen Aboriginal men whom he described as being "perfectly naked, having no covering" (Kenny 1995: 104). In 1658 Jacob Pieterszoon became the first European to land on the southern shores, at Geographe Bay near Cape Leeuwin (latitude 33˚S). In contrast to the Aborigines further north, Pieterszoon's journal reports the inhabitants as being "hung with skins like those of the Cape de Bonne Esperance [Cape of Good Hope]" (Heeres 1899: 81).

There is some evidence for apparently non-thermal clothing use by Aborigines in northern coastal areas, with a few of the earliest records reporting girdles or loin coverings, at least among some of the women. Dampier spent over two months on the northwest coast in the summer of 1688, and his journal makes the following observations:

> *They have no sort of Cloaths, but a piece of the Rind of a Tree tied like a Girdle about their Waists, and a handfull of long Grass, or three or four small green Boughs full of Leaves, thrust under their Girdle, to cover their Nakedness*
>
> (Dampier 1729: 313)

Around the Gulf of Carpentaria, and on Melville and Bathurst Islands (latitude 11˚S), there are a number of instances where at least some of the women are described as wearing waist garments, suggesting decoration or perhaps even a vestige of "modesty" as a function. In 1705 van Delft observed:

> *...but they go stark naked without any regard to age or sex, as was constantly observed by our sailors... The only exception to this rule were the women who had children with them, these alone wearing a light covering of leaves or such-like over their middle*
>
> (Major 1859: 126-127)

Also, on the western side of Cape York, Gonzal in 1756 reported seeing "a number of females who had their privities covered with a kind of small mats" (Heeres 1899: 94).

Cook charted most of the eastern coast of the continent (between 38˚S and 11˚S) during the autumn and winter of 1770. With the exception of ornamental items such as necklaces, nose bones, bands tied round their arms or waists, or feathers or shells stuck in their hair (and these were exceptions, bodily adornment being restricted mainly to scarification and painting), the Aborigines' total lack of clothing throughout the entire length of the eastern coastline was emphasised:

> *That their customs were nearly the same throughout the whole length of the coast along which we saild I should think very probable. Tho we had Connections with them only at one place [Endeavour River, 15˚S] yet we saw them either with our eyes or glasses many times, and at Sting Rays bay [Botany Bay, 34˚S] had some experience of their manners; their Colour, arms, method of using them, were the same as we afterwards had a nearer view of; they likewise in the same manner went naked, and painted themselves... Our glasses might deceive us in many things but their colour and want of cloths we certainly did see...*
>
> (Banks 1998: 97-98)

Banks' reaction to Aboriginal nakedness focussed on the philosophical problems created (in European minds) by their total lack of any physical modesty, discussed in the flowery language of a botanist, and managing a botanical reference in his Biblical allusion:

> *Of Cloths they had not the last part but naked as ever our general father was before his fall, they seemed no more conscious of their nakedness than if they had not been the children of Parents who eat the fruit of the tree of knowledge*
>
> (ibid: 99)

Cook eschewed such metaphysical conundrums and took a typically pragmatic line, reflected a seaman's appreciation of the importance of the natural elements:

> *...they live in a warm and fine Climate and enjoy a wholesome Air, so that they have very little need of Clothing and this they seem to be fully sencible of, for many to whome we gave Cloth &c to, left it carelessly upon the Sea beach and in the woods as a thing they had no manner of use for*
>
> (Beaglehole 1955: 399 [also Wharton 1893: 323])

Cook however did not see any of the Aborigines who lived beyond the narrow coastal fringe, where the climate is moderated by proximity to the warm waters of the Pacific Ocean. Contact with the inland groups began only after the establishment of the first British settlement at Sydney Cove, Port Jackson (latitude 33˚52'S) in 1788. Eleven journal accounts survive from those who arrived in the First Fleet. With one or two minor exceptions, they are unanimous in describing the local Aborigines as being completely without clothes (e.g. Stockdale 1790: 163, Hunter 1793: 56-59, Collins 1798: 452, Phillip 1892a: 129, 131, Easty 1965: 88, Bradley 1969: 58-61, Worgan 1978: 13, Smyth 1979: 57-58, King 1980: 32-35, Tench 1996: 41-53). There is also the journal of the ill-fated La Pérouse, who anchored for six weeks in Botany Bay just as the First Fleet arrived. It gives only a brief account of his sojourn, and ends abruptly

without any mention of the Aborigines, although in a letter sent to Fleurieu dated 7 February 1788 he depicted them as "very weak and not numerous" and "very ill-natured" (La Pérouse 1995: 539). Of the First Fleet journals, only that of Scott makes no mention of Aboriginal nakedness or use of clothing, other than to report that after "Manly" was taken captive at Manly Cove in December 1788, the Governor Phillip "Cloathed him & Made him Dine with him" (Scott 1963: 44).

There are a few reported exceptions to Aboriginal nakedness in the Port Jackson area during the first year of British settlement. (White 1790: 186, 198, 205). Bradley noted an old woman and a young boy who alone were "not entirely naked", and these he said "seem'd to be lame" (Bradley 1969: 139). In July 1788 the surgeon White describes a young girl in a canoe who "wore a complete apron", "an instance of female decency, as we had not at any other time observed among the natives" (White 1790: 186). At Broken Bay in August of that year he saw numerous Aborigines, one of whom "wore a skin of a reddish colour round his shoulders", presumably a kangaroo-skin cape (ibid: 198). He also observed that the female children "wore a slight kind of covering before them, made of the fur of the kangaroo, twisted into threads" (ibid: 205). These are indeed exceptions to the rule for the Port Jackson area.

Two trends begin to emerge from the ethnographic evidence even at this early stage of the colonial era. First is the likely influence of the European presence, exemplified by the increasing occurrence of Aboriginal theft of European-style clothes and blankets during the early years of the settlement, documented for instance in the account of the colony by Collins. The Aborigines became increasingly aware of the foreigners' notions of decency with respect to body covering, and began to alter their behaviour as a consequence, at least in the presence of settlers:

> *They had also discovered that we thought it shameful to be seen naked; and I have observed many of them extremely reserved and delicate in this respect when before us; but when in the presence of only their own people, perfectly indifferent about their appearance*
> (Collins 1798: 464)

Another trend is the evidence for greater use of clothing as thermal protection by Aborigines residing away from the coast. This applies even within the environs of Port Jackson, where the difference in temperature ranges between the coast and the Nepean River, 50 km to the west, or along the Georges River 30 km to the southwest, surprised the settlers. Even the temperature difference between the settlements at Rose Hill (now Parramatta) and Sydney Cove, separated by only 20 km and a few minutes of latitude, was remarked upon (e.g. Tench 1996: 232).

In a letter dated 13th February 1790, Governor Phillip reported the finding of an Aboriginal cloak at Richmond Hill, near the Nepean River:

> *The native fires are frequently seen on the tops of the mountains, where the air in winter must be very sharp; and a small cloak has been found, made of the skins of the opossum and flying squirrel, very neatly sewed together, the inside ornamented in diamonds of curved lines, by raising the skin with the point of a small bone, which is made sharp for that purpose. This cloak they put over their heads when they sleep - and cloaks made beating the bark of the brown gum-tree are common, and used for the same purpose, or to keep the rain from their heads and shoulders*
> (Phillip 1892b: 310)

The ethnographic evidence for geographical trends in Aboriginal clothing on the mainland, both with respect to distance from the coast and changing latitude, is central to evaluating the Tasmanian clothing paradox. However the influence of the British presence complicates the situation. It has the potential to interact with the ethnography, both geographically (in terms of proximity to settlers and contacts with explorers inland) and temporally, with the evidence becoming less reliable with each successive decade after 1788. For this reason, the early inland expeditions are of particular value here. One is Oxley's journey along the Lachlan River, some 300 km west of Sydney, in the autumn of 1817. In the vicinity of Cowra (latitude 33˚40'S) he encountered eight male Aboriginal men:

> *They were very stout and manly, well featured, with long beards: there were a few cloaks among them made of opossum skin, and it was evident that some of the party had been at Bathurst, from their making use of several English words, and from their readily comprehending many of our questions*
> (Oxley 1820: 8)

This problem of reduced reliability of the ethnographic evidence in the early colonial era arises for the southeastern mainland adjacent to Bass Strait, where it is most crucial for the Tasmanian clothing paradox. The first contacts between Europeans and Aborigines in this region did not take place until more than a decade after the establishment of the settlement at Port Jackson. Despite being separated by a distance of some 1000 km, the possibility of an indirect European influence on Aboriginal behaviour with respect to clothing cannot be entirely discounted. Nonetheless, there is some consistency in the reports of the use of opossum skin cloaks in particular, even in the coastal areas around Port Phillip (latitude 38˚S). The coastline in this region is exposed to colder winds and ocean currents than is the eastern seaboard, so indigenous clothing might be anticipated even along the coast. The first European visits to Port Phillip occurred in 1802, with John Murray arriving in February and Matthew Flinders arriving ten weeks later. Murray's men presented the locals with European garb in the form of white shirts, and they bartered these and other gifts in exchange for some Aboriginal artefacts including cloaks. They saw no women, but Murray reports all the men as wearing cloaks, which impressed him as being well-made (Murray 2002: 28).

In April 1802 Baudin entered Western Port, immediately to the east of Port Phillip, encountering a number of Aborigines during the eight-day visit:

> *Of thirteen savages, whom our company saw, only one was covered with a black skin: the rest were entirely naked*
>
> (Péron 1809: 269)

The "black skin" was presumably a fur cloak made from opossum skins, judging from subsequent reports. Earlier, in the summer of 1788, Bass had charted Western Port during his whaleboat voyage. Bass's account is brief and makes no mention either of cloaks or nakedness, although he does remark that the behaviour of the Aborigines suggested to him that "they had never seen white people before, or ever heard of them" (Bass 1895: 42).

**Shelter**

The First Fleet journals document a limited but nonetheless appreciable need among the Aborigines for the protection afforded by shelter, notably with regard to the combined thermal effects of low temperatures, wind and rain. Natural as well as artificial shelters were utilised:

> *It does not appear that these poor Creatures have any fixed Habitation, sometimes sleeping in a cavern of a Rock, which they make as warm as an Oven by lighting a Fire in the middle of it, they will take up their abode here, for one Night perhaps, then in another the next Night, at other times (and we believe mostly in y$^{e}$ Summer) they take up their Lodgings for a Day or two in a miserable Wigwam, which they make of the Bark of a Tree...*
>
> (Worgan 1978: 15-16)

Tench describes the latter:

> *Than these huts nothing more rude in construction or deficient in conveniency can be imagined. They consist only of pieces of bark laid together in the form of an oven, open at one end and very low, though long enough for a man to lie at full length in. There is reason, however, to believe that they depend less on them for shelter than on the caverns with which the rocks abound*
>
> (Tench 1996: 53)

Elsewhere on the mainland, the Aborigines also constructed artificial shelters of various descriptions. Along the western part of the southern coast, where opportunities for natural protection in the form of rock shelters and caves were generally fewer, more durable huts may have been used. The first European to chart this coastline was Vancouver, who sought refuge from high winds and rough seas in King George Sound (latitude 35˚S), during the spring of 1791. He did not meet with any of the local inhabitants, but he found abundant evidence of their pres-ence in the area, including huts. These, though "miserable" in his view, may have been less so than those constructed in more clement conditions:

> *At the borders of this clump was found the most miserable human habitation my eyes ever beheld, which had not long been deserted by its proprietor...the shape of the dwelling was that of half a beehive, or a hive vertically divided into two equal parts, one of which formed the hut, in height about three feet, and in diameter about four feet and a half; it was however constructed with some degree of uniformity, with slight twigs, of no greater substance than those used for large baker's baskets: the horizontal and vertical twigs formed intervals from four to six inches square, and the latter sticking a few inches into the earth, were its security and fixed it to the ground. This kind of basket hut was covered with the bark of trees, and small green boughs; its back was opposed to the N.W. whence we concluded those to be the most prevailing winds; just within its front, which was open the whole of its diameter, a fire had been made...*
>
> (Vancouver 1798: 33-34)

In contrast to Europeans, the Aborigines had little inclination to use habitations (whether artificial or natural) other than when immediate environmental conditions made life in the open uncomfortable. As with their habitual nakedness, the ethnographic record indicates they felt quite at home when exposed to the elements, with neither clothes nor walls separating them from their surroundings. In a literal as well as a symbolic sense, they enjoyed and valued an intimate and casual physical relationship with the natural environment. Much to the puzzlement of the Europeans, they initially showed no desire to embrace the comforts and securities offered by a regulated existence within the insular world being fabricated within the white settlements.

This reluctance to be enclosed by an artificial environment is seen in the ethnographic record, in the response of Aborigines who were encouraged (or, as in this instance, coerced) to live in European-style permanent dwellings. At Governor Phillip's instigation, a number of Aborigines were taken into custody in the early days of the settlement, with the intention of demonstrating to their countrymen that adopting a European lifestyle had advantages, and that they could become assimilated into the colony. The most well-known such recruit was Bennelong, who was befriended by the Governor after his capture, and who developed a liking, albeit an ambivalent one, for all the trappings of "civilisation", including decent tailored clothing. He was granted free access to the Governor's house, where he spent much of his time when in the settlement. In 1790 a house was built for him on the eastern side of Sydney Cove. Bennelong lived intermittently in this house, and even accompanied the governor to England in 1792, returning three years later:

> *Bennillong had certainly not been an inattentive observer of the manners of the people among whom he had lived;... His dress appeared to be an object of no small concern with him; and every one who knew him before he left the country, and who saw him now,*

> *pronounced without hesitation that Bennillong had not any desire to renounce the habits and comforts of the civilized life which he appeared so readily and so successfully to adopt*
>
> (Collins 1798: 367)

In reality, Bennelong's attitude to European dress and housing was always vacillating, even after his return. He began to disappear from the settlement, shedding his garments as he went:

> *His absences from the governor's house now became frequent, and little attended to. When he went out he usually left his clothes behind, resuming them carefully on his return before he made his visit to the governor*
>
> (ibid: 368)

Bennelong was proud to have his house, as he was proud to don European costume, but he never became fully accommodated to either. He evidently preferred life in the open air, even on chilly winter nights when the Europeans needed the protection of clothes and a roof over their heads. Along with his habitual nakedness, Bennelong's house now belongs to the past. In its place, standing proudly on the peninsula named in his honour, stands a house with a roof that looks instead to the future: the Sydney Opera House.

# Chapter 3 Thermal issues

Before tackling the Tasmanian clothing paradox and its related issues, two areas of background material need to be presented, as the studies to follow will draw upon certain principles and findings from these fields. The first is the field of human thermal physiology, specifically human cold tolerance and responses to cold exposure. This includes both the thermal physiology of clothing and the findings that relate to Aboriginal cold tolerance. The second field is the research in physical anthropology on the thermal aspects of human morphological variation, and the implications of these findings for the Australian Aborigines in terms of morphological cold adaptations.

## Cold tolerance and clothing requirements

The principles and experimental findings relating to human responses to varying thermal conditions are documented in an extensive literature (e.g. Wulsin 1949, Burton and Edholm 1955: 182-189, Edholm and Lewis 1964: 445, Brück *et al.* 1976: 131-132, Fanger *et al.* 1977: 49, Little and Hanna 1977: 123, Mount 1979: 145-181, Hensel 1981: 227, Collins 1983, Robertshaw 1981, Young 1996, Jessen 2001, Parsons 2003: 293-325).

Most studies have examined human subjects who habitually wear clothes, and so the findings will underestimate cold tolerance among humans who are (or were) routinely unclothed. Some studies provide data on Australian Aborigines, before the adoption of European-style tailored garments, and these are reviewed later. The data from studies of habitually-clothed modern humans demonstrate that thresholds exist beyond which unclothed humans perceive conditions as distinctly cool or cold, and limits are defined beyond which physiological responses prove inadequate.

The ideal thermal conditions for modern-day humans are decidedly tropical, at least in terms of temperature if not humidity. Unclothed humans typically begin to feel cool when the temperature falls to just 27°C, and the optimal ambient temperature for lightly-clothed people is around 25°C (Fanger 1970: 130-131). Below this point the human body starts to conserve heat, more so once the ambient temperature falls below 20°C (Edholm 1978: 26, Clark and Edholm 1985: 156). For an unclothed human standing still in wind-free conditions, shivering begins at around 13°C (Hardy *et al.* 1971). With even a slight breeze, the wind-chill index means that the effective temperature and duration of safe exposure is further reduced; a wet skin surface adds to wind chill due to evaporative heat loss, meaning that humans in cold environments need shelter from both wind and rain (Burton and Edholm, 1955 111-112, Clark and Edholm 1985: 197). Data from laboratory studies and reports on accidents in the cold show how exposure leads rapidly to death (Pugh 1966, Collins 1983, Clark and Edholm 1985: 159-161, Purdue and Hunt 1986, Tanakaand& Tokudome 1991, Danzl 1998a, Jessen 2001: 164-166).

In addition to hypothermia, cold exposure can result in localised injury, of which the most well-known is frostbite. A milder form of frostbite is chilblains, causing localised swelling and sometimes ulcers. Frostbite can occur with short-term exposure to temperatures above -10°C, and with prolonged exposure to temperatures even a little above 0°C (Frazier 1945: 252-253, Orr and Fainter 1952, Burton and Edholm 1955: 231, Lapp and Jurgen 1965, Smith 1970, Velar 1970, Edholm 1978: 42, Grayson 1990: 228-230, Denzil 1998b).

Cold tolerance can be improved through acclimatisation, which leads to delayed shivering, lower metabolic rates, and increased tolerance of lower skin and core temperatures. Acclimatisation has been documented under experimental conditions, among people working in Antarctica, in those such as pearl divers who experience repeated short-term cold exposure, and also among high-latitude populations, though it does not greatly alter the lower limits of cold tolerance (Wulsin 1949: 35, Burton and Edholm 1955: 182-189, Scholander *et al.* 1958a, Brück *et al.* 1976, Little and Hanna 1977, Bodley 1978, Doi and Kuroshima 1979: 139-147, Dawson *et al.* 1984, Ruwe *et al.* 1984: 132, Brück 1986, Silami-Garcia and Haymes 1989). In general, routinely unclothed populations show superior acclimatisation (Steegmann 1975: 139-162, Sloan 1979: 42-44, Mathew *et al.* 1981, Young 1996). Acclimatisation, however, is “of little use during intense and continuous exposure”, and the human thermoregulatory system is, in its capacity to respond to cold, “definitely inferior to that of other mammals” (Jessen 2001: 152).

Humans can adapt to the cold, but only down to a “critical level” (Hensel 1981: 220). There are effective air temperatures below which hypothermia can begin within a few hours, and sooner if there is even a slight wind (Hensel *et al.* 1973). While many variables will influence cold tolerance in any particular situation, and there is no one single temperature that can be termed a fixed “limit” as such, the practical safe limit for modern-day clothed humans, beyond which the risk of hypothermia can become acute, occurs at around **-1 ºC**.

For habitually unclothed humans fully acclimatised to cold, the lower limits have not been experimentally determined. Ethnographic studies indicate that tolerance of cold for such peoples will extend a few degrees further below zero, at least for short-term exposure without strong winds, i.e. to around **-5 ºC**.

### Australian Aborigines

Australian Aborigines possess distinctive physiological responses to cold which, in addition to acclimatisation, allowed them to endure mild cold exposure with little if any clothing. Researchers examined male Aborigines who were still routinely unclothed in central Australia, where the minimum recorded temperature was -4°C. Unlike white subjects, the Aborigines’ metabolic rates tended to decline during the cold nights, and they could tolerate greater skin cooling without discomfort (Hicks et al 1931, Goldby *et al.*

1938, Scholander *et al.* 1958b). The findings were interpreted as showing greater control of heat loss being favoured over a "wasteful" increase in metabolic heat production (Hicks 1964: 411). Northern coastal Aborigines showed an attenuated pattern of reduced metabolism and lower skin temperatures on cold exposure (Hammel 1964: 418-419), suggesting that tolerance of mild to moderate cold might have been more pronounced among Aborigines of the southern regions, and possibly in Tasmania. In general, Aborigines allow their bodies to become cooler, especially the outer "shell" which, by reducing the thermal gradient, slows the rate of heat loss and serves to insulate the body core. While this may be adaptive for hunter-gatherer peoples in that it reduces caloric requirements, it would be decidedly risky in colder environments involving more prolonged exposure to lower temperatures, especially with greater wind chill.

The so-called "hypothermic" cold response of Australian Aborigines contrasts with the "metabolic" response seen in most other human groups. The latter involves increasing heat production through a higher metabolic rate, up to double the basal metabolic rate on mild cold exposure (down to 0°C), which demands a higher caloric intake. Skin and core temperatures are maintained close to normal. This pattern is seen among cold-acclimatised peoples such as Eskimos and the Lapps of Norway, and also in Europeans when they become acclimatised to cold over a period of a few weeks. A "hypothermic" response has been found in only one other human group, the Bushmen of the Kalahari although, unlike Australian Aborigines, they do not allow their skin temperatures to fall much below those of Europeans (Wyndham and Morrison 1958: 225, Hammel 1964: 419).

An extreme example of human cold adaptation involves the inhabitants of Tierra del Fuego, at the southern end of South America (latitude 54°S). They exhibit cold-adapted physiological responses including elevated metabolic rates, and also morphological adaptations to cold. In contrast to the Australian Aborigines, whose linear body build is suited to tropical environments, the indigenous peoples of the Americas generally have more stocky body proportions, presumably reflecting selection for cold climate adaptations among their ancestors in northeastern Eurasia late in the Pleistocene (Ruff 1994: 79, Merriwether *et al.* 1996: 210). Whilst Charles Darwin was astonished by their ability to live "naked" in the "damp and boisterous" climate (Darwin 1839: 234-235), they also had behavioural adaptations including shelters made from tree branches, guanaco pelts and seal skins, and they generally wore sealskin capes and long robes of woolly guanaco skins. Such adaptations are hardly surprising given the thermal conditions. Meteorological data for Punta Arenas (53°10'S) show a mean annual temperature of 6.5°C, mean July temperature 1.9°C, and a recorded minimum of -11.7°C (Lamb 1972: 554). Such conditions can be dangerous, even in summer. On his first Pacific voyage, prior to landing on the east coast of Australia in 1770, James Cook visited Tierra del Fuego in January 1769. A group of Cook's men became lost on shore overnight, and the next morning two had succumbed to hypothermia, their bodies being found in the woods, "frozen to death" (Parkinson, 1784: 9-10).

**Wind chill**

The concept of wind chill relates to the cooling effect of air movement on skin surface temperatures. The original wind chill index (Siple and Passel 1945: 181-187, Siple 1945: 209-210) was derived from experiments in Antarctica based on the time taken for a cylinder of water to freeze under varying atmospheric conditions. Physiological experiments show that at 15°C, the presence of wind has a greater chilling effect than a fall in ambient air temperature to 10°C, and lowering humidity has an additional chilling effect. Even moderate wind speeds around 15 km/hr (4 m/s) can result in hypothermic responses for exposed humans, at 15°C, within 1-2 hours (Iampietro *et al.* 1958: 355).

Although adopted widely, the original (Siple) index overestimates the risks for humans in real-world situations. It makes no allowance for factors such as humidity and metabolic heat production, and takes no account of the fact that most people usually wear clothing (Burton and Edholm 1955: 111-112, Steadman 1971, 1979a, 1979b, 1995, de Freitas 1985, Kaufman and Bothe 1986, Dixon and Prior 1987). Despite its flaws, the Siple index corresponds closely with subjective sensations of cold discomfort, especially on the exposed face (Osczevski 1995). More realistic estimates of the cold injury risks for modern-day humans are provided by revised thermal comfort and wind chill scales, e.g. the Apparent Temperature (AT) scale (Steadman 1984), the Steadman wind chill scale (Quayle and Steadman 1998: 1190), and the Wind Chill Temperature (WCT) index released for the 2001/2002 winter season in North America (www.erh.noaa.gov/er/iln/tables.htm). These revised scales relate to humans who wear clothing, which presents two problems. On the one hand, indices based on these data will exaggerate the risks for routinely-unclothed humans, whose cold tolerance is superior; on the other hand, the wind chill effect will be more severe for humans without fitted clothing. To some extent, these two sources of error should tend to balance out for pre-contact Australian Aborigines.

**Clothing requirements**

The thermal insulating properties of clothing, which are detailed in various studies of clothing physiology (e.g. Newburgh 1949, Burton and Edholm 1955: 58, Fourt and Hollies 1970, Hensel 1981, Watkins 1984), are based on a few fundamental principles. Like every warm-blooded mammal, humans lose heat from the skin surface if the outside environment is cooler than the body. The heat is lost in various ways, such radiating heat directly to the outside and conducting it through any medium in contact with the skin, be it solid, liquid or gas. The more dense the medium, the more rapidly it transmits heat. This is why metals, be-

ing very dense solids, feel cold to touch at room temperature. Air on the other hand is much less dense so it offers greater thermal resistance, meaning it resists the conduction of heat. Water, being more dense than air, cools the skin more rapidly than air at the same temperature.

It is not so much the material of clothing that diminishes heat loss, but the layers of air trapped next to the skin (Burton and Edholm, 1955: 58). Being of low density, still air conducts little heat, and it is this property of thermal resistance in trapped layers of air that gives clothing its insulatory quality. With or without clothing, there is a very thin layer of still air next to the naked skin, caused by frictional drag. The skin heats this layer, and heat is lost depending on ambient temperature and air movement beyond the closest layer. If this air is moving, as it is under most conditions – due to wind, body motion, and convection currents – the skin loses heat continuously to cooler airstreams around the body.

Clothing consists of solid material, but its loose structure traps tiny pockets of air. Most importantly, it traps a thin layer of air next to much of the skin surface. This air is warmed by body heat, in the same manner as air in contact with the naked skin. But whereas air next to naked skin moves away freely through convection, carrying body heat with it, much of this warmed air is trapped by clothes. It warms almost to body temperature, reducing the thermal gradient between the skin and the environment, and so reducing the rate of heat transfer. The natural fur of other mammals works in much the same way, trapping pockets of warm air between the fibres. Heat is still lost from the surface of clothing, but at a slower rate due to the lower gradient, and the loss can be further diminished by adding extra layers of clothing.

The main routes of heat loss from the human body are radiation, conduction, convection and evaporation. Of these, convection and evaporation are the most variable and, in cool environments where sweating is reduced, convection accounts for the bulk of heat losses from the body. This is the route that is most affected by clothing. In slowing the movement of air layers around the body clothing reduces the amount of heat lost through convection, allowing the inner layers to become warmer with body heat until little further heat is lost from the skin surface.

In short, clothing functions as thermal insulation primarily by trapping air in layers and tiny pockets close to the skin. Two measures of the thermal effectiveness of clothing are:

1. The total *thickness* of clothing, which gives an approximate measure of how much still air is trapped near the skin. Most of the insulatory effect comes from the air between the layers of material, and air trapped within the fibres of each layer is of less importance. The choice of material for each layer is affected more by issues such as comfort, weight, flexibility, and permeability to sweat and wind, than by any thermal qualities of different materials themselves.
2. The effective thermal resistance of clothing, indicated by the *clo* unit, has been determined experimentally for a seated person (body surface area in $m^2$) at a temperature of 21˚C, with air movement of 0.1 metre per second:

$$1\ Clo = 0.18\ ^{\circ}\mathrm{C/kcal/m^2/hour}$$

(Gagge *et al.* 1941: 429)

Generally speaking, each extra layer of clothing adds nearly one clo: donning an overcoat provides about 2 clo of insulation, while Arctic clothing (4 layers) provides about 4 clo of thermal protection (Sloan 1979: 17).

The more layers of clothing, the more air is trapped next to the skin surface. In addition to providing more warmth, an advantage of wearing multiple layers is that they can be added or removed as required (Siple 1945: 226, Clark and Edholm 1985: 203). The fingers are a possible exception, where the use of even a single layer of insulation compromises dexterity, and may also have a paradoxical exacerbating effect on heat loss. Adding a layer of insulation of given thickness to any cylinder of very small diameter can greatly increase net heat loss due to the proportionally greater increase in effective surface area, but this factor is of less significance for larger entities such as the limbs and torso (Burton and Edholm 1955: 62).

Even in Arctic environments, three or four layers of clothing are sufficient to keep people warm, though five layers may be needed in a blizzard. People still have to find shelter at some point and heat it, but while they are outdoors the body heat they generate can replace the heat lost from their outer garments for hours at a time.

To be effective, clothes must not only trap air but also keep it still. Any air movement due to wind or body motion reduces the thermal efficiency of clothes. The use of extra layers of clothing, and the advent of fitted sewn garments, were crucial advances in this regard, since these trap more air, and they do so more effectively. Protection from air movement is a critical factor in thermal insulation. In windy conditions, the number of layers and the fitting of the garments reflect the need for protection from air movement as well as from the cold. Any movement of air, even within the layers of air under clothing, greatly reduces the thermal effectiveness of clothing. For this reason, it is crucial to take account of both air temperature and air movement in determining clothing requirements. As outlined above, the effective thermal stress of a cold environment, which is largely a function of temperature and wind velocity, is measured by the wind-chill index. Besides wind, the other aspect of air movement is body motion. Measurements of clo values are based on people standing or sitting motionless in wind-free environments. Just as wind reduces clo values dramatically, so too does air movement resulting from physical activity. Insulation can be reduced by nearly 50% when walking briskly (Fourt and Hollies 1970: 104). Physical activity puts special demands on clothing which tend to defeat its thermal function. Perspiring not only has

a cooling effect, but it adds weight and makes clothing cling to the skin, rendering physical activity more difficult. Motion itself creates air movement within the clothes, known as the "bellows" effect, which adds to convective heat loss. While activity increases metabolic heat production it also increases heat losses, and it requires more flexible and less bulky garments. There is little point in people being insulated by clothes if they can hardly move around or use their hands. Physical activity may be necessary to get food, and also to get the raw materials for making clothes, but it creates serious thermal problems with clothing (Siple 1949: 438, Fourt and Hollies 1970: 42-44,Sloan 1979:17, Goldman 1981: 48). The cooling effect of body movement is not always a disadvantage, since the increased heat production associated with physical activity will reduce insulatory requirements, and also such air movement will help to evaporate sweat before it accumulates. Whilst it may seem incongruous to be concerned about sweating in a cold environment, any physical activity within the warm microenvironment of the clothed body generates considerable heat and sweating. Physical exertion results in clothes becoming wet with perspiration, which diminishes thermal insulation due to cooling from evaporation (Forbes 1949). The heavier the clothing, the sooner sweating begins, and the more profuse is the sweating that accompanies physical exercise (Jeong and Tokura 1989). This evaporative cooling from perspiration-soaked clothing can exacerbate the chilling effect of wind up to sixteen times (Fourt and Harris 1949: 310-316). Moisture accumulation from sweating also displaces the trapped air in clothing, further reducing insulation (Fourt and Hollies 1970: 87). To combat the chilling effects of perspiration on clothing it is imperative that clothing be permeable to some extent, despite the risks of penetration by wind (Burton and Edholm 1955: 69). In this respect, woven textiles confer a real advantage compared to animal hides and furs, though the use of natural fibres to manufacture cloth did not become commonplace until the advent of pastoralism, horticulture and farming after the end of the last ice age. Moreover, garments made from woven materials, being more permeable to both perspiration and air movement, were more appropriate for humans who, for whatever reasons, preferred to wear clothing in the warmer post-glacial environments. In general, sweating would be greater and wind chill less of a concern – the latter in fact would confer some advantage in permitting added cooling for those wearing clothes in warm environments.

**Simple *vs.* Complex Clothes**

A distinction can be made between what may be termed "simple" as opposed to "complex" clothing. The distinction is based on physiological principles, but it has important ethnographic and, particularly, archaeological implications. The physiological distinction arises from two aspects that largely determine the thermal effectiveness of clothing. First, whether a garment is properly "fitted", i.e. shaped to fit closely around the body, including the limbs, as opposed to being loosely draped over the body, leaving the limbs less protected. The second aspect is the number of layers of garments, with multiple layers requiring that at least the inner layer(s) are fitted. Or, put another way, if only draped garments are in use, practical considerations will mean that such clothing is generally restricted to a single layer. Draped, single-layer clothing can provide limited protection, up to 1-2 clo, whereas fitted, multilayered clothing assemblages can provide up to 4-5 clo, sufficient for survival in polar and sub-polar environments. The former may be termed "simple" clothing, and the latter "complex".

This distinction tends be both an ethnographic and an archaeological one, since there are fundamental technological differences between simple and complex clothes. Where the raw materials are animal skins, simple garments require little more than basic skin-preparation techniques, mainly cleaning and scraping, which can be achieved with scraper tools of various descriptions. Complex garments, however, demand that the skins be shaped, which usually means they need cutting, especially in making the separate cylinders to cover the limbs, and these need to be joined together in some way, usually by sewing. Where multiple layers are used, the inner garments need to be more carefully prepared, with finer cutting and sewing to achieve the necessary close fit. Complex clothes, in other words, will tend to be associated with more specialised scraping, cutting and sewing implements.

Where raw materials other than animal skins are involved, most commonly either beaten bark cloth, or woven (textile) cloth, complex garments can often be manufactured more easily, especially with textiles, where the cloth itself can be manufactured in differing shapes and sizes. These technologies, for various reasons, tend not to be found among mobile hunting and gathering peoples, and are associated with more sedentary communities.

The archaeological implications of this distinction between simple and complex clothing will be pursued later, though mention can be made of technological, demographic and socioeconomic implications. In a Pleistocene context, technocomplexes with dedicated scraping, cutting and hide-piercing tools – traditionally classed as "upper palaeolithic" – will be better placed to manufacture complex clothing, while humans without such clothing will be restricted in terms of their potential environmental range for thermal reasons. Minimal clothing requirements can, to some extent, be predicted from physiological principles in concert with palaeoenvironmental data, which means that despite its archaeological invisibility in most circumstances, the existence of clothing, and even the basic form of such clothing and its technological correlates, may be predicted with some confidence. In relation to palaeoanthropology, simple clothing was probably used by archaic humans and Neanderthals (and continued in use among many recent mobile hunter-gatherer peoples), while complex clothing was acquired by some groups of fully modern humans in the Upper Pleistocene.

One interesting aspect to the distinction is that complex clothing results in the human body becoming more completely, and routinely, covered. Not only does it cover more of the skin surface, and not only is it more cumbersome to remove, it also results physiologically in a more uniformly warm microenvironment around the body, leading to greater impairment of cold tolerance, all of which tends to result in its being worn on a less sporadic basis. This in turn means that body adornment for social purposes will need to shift from decorating the naked skin surface to decorating the garments, favouring the development of cultural motives for wearing clothing independent of any thermal contingencies. At a psychological level, regular use of clothing, especially from an early age, may also promote the emergence of a sense of shame or modesty in relation to the naked body, which again will tend to encourage the use clothes at a social level in addition to, and even regardless of, environmental conditions.

Ethnographically, the Australian Aborigines utilised only what is herein termed "simple" clothing. The garments were draped, not fitted, and only a single layer of covering is documented. From a thermal perspective, it would appear that nothing more was needed, although it remains to be seen whether the Tasmanian Aborigines somehow managed with what might be considered even less. There is little evidence for any of the non-thermal or "cultural" functions that, it is suggested, are likely to develop with "complex" clothing. Again, however, it remains to be seen whether there were exceptions to this generalisation, even in the pre-colonial era. As discussed later, there may be some indications of non-thermal functions at the other, northern, end of the continent.

## Morphological cold adaptations

As outlined above, among the factors that will affect cold tolerance for both mainland and Tasmanian Aborigines are the general physiological responses of humans to cold exposure and the limits of those responses. These limits will be modified somewhat by acclimatisation and the likely effects of habitual nakedness, as well as any special adjustments or responses, including the "hypothermic-insulative" pattern shown to exist among at least some mainland Aboriginal groups (and which may or may not pertain among the Tasmanian Aborigines). An additional factor to be taken into account, one which is known to affect cold tolerance not only in humans but in all warm-blooded animal species, is the influence of morphology.

Studies in physical anthropology have shown that a number of human morphological features, of which body shape, body mass, and relative limb proportions are prominent, correlate with thermal conditions. This applies both on a global scale, for the human species as a whole, and also on a continental or regional scale, within particular human groups. In the past, some of this predictable variation in body form has been construed (and misconstrued) as evidence for "racial" groupings (even in the Australian context), so it is important to appreciate why these trends should be found.

The historical background to research on thermoregulatory aspects of human morphological variation is reviewed by Ruff (1994), who also provides a summary of the relevant physiological principles. In brief, body form affects human thermal requirements by virtue of the ratio between skin surface area and body volume, or mass. Body volume plays a major role in total heat production (through metabolism), while surface area is a major determinant of total heat loss (through direct radiation, conduction, convection and – especially with sweating – evaporation). Even minor variations in body form (shape and size) are significant for thermoregulation because surface area and volume do not vary in equal proportions to each other. Volume varies as the cube, whereas surface area varies as the square, of any linear change in size. This means that a smaller body size will be conducive to heat loss, while a larger size will be more conducive to heat gain. In relation to body shape, a more spherical (or endomorphic) form will reduce heat loss, while a more elongated (or ectomorphic) form will enhance heat loss. Overall, these thermal implications of morphology should lead to a lighter and more slender (or linear) body build in warmer environments, and to a heavier and more stocky (or lateral) body build in colder environments. Also, environmental factors including humidity and, to a lesser extent, exposure to air movement and solar radiation, can exert an influence on morphology and other physical features (e.g. skin pigmentation). These additional environmental factors (notably humidity) may be of some relevance to mainland and Tasmanian Aboriginal morphology, as discussed in more detail in the Introduction to the morphology section (Study 2) below.

The relationship between thermal environment and morphology has been expressed in zoology as a number of "rules". The first is Bergmann's rule, which states that "the larger animals are, the less heat they must produce relative to their size", with the result that, other factors being equal, larger size is favoured in colder environments (Bergmann 1847: 601). A related rule refers to the size of body appendages, notably limbs: "certain parts of the organism vary more than does general size, there being a marked tendency to enlargement of peripheral parts under high temperature, or toward the tropics" (Allen 1877: 116).

### Aboriginal morphology

While the Australian Aborigines as a group are morphologically "tropical" (with even their "hypothermic" physiological cold response being interpretable as an economical adaptation to limited cold exposure), their morphology (body shape and limb proportions) should nonetheless manifest the same correlation with temperature seen in other groups and in the human species overall. Indeed there are a number of *a priori* reasons for expecting that the Aborigines are likely to conform to the predicted pattern of morphological variation across the continent. These same considerations should apply to the Tasmanian Aborigines, and particularly so given that their circumstances were in some respects rather different from those of the mainland Aborigines.

The main aspects of Aboriginal morphology that may be expected to show variation along thermal gradients are body shape and limb proportions, reflecting Bergmann's and Allen's rules, respectively. Any trends in these metrical traits should show a gradual, or clinal, pattern that correlates with mean annual (or mean summer and winter) isotherms, and this should extend to Tasmania. It would also be of interest to know whether other traits such as basal metabolic rate, head shape and so on, which are known to vary with thermal gradients in most other human groups, show a similar clinal distribution among Australian (including Tasmanian) Aborigines.

It needs to be recalled that natural selection can operate only on pre-existing phenotypic variation: it cannot in itself generate new "adaptations". At most, selection for improved cold tolerance among Aborigines in cooler regions might lead to relatively minor modifications of their "tropical" linear build, towards a somewhat stocky or lateral build, and a reduction in relative limb proportions, among the southern groups. This is comparable to (but the reverse of) the situation in the Americas where, aside from the shorter timespan available for selection compared to the duration of the human presence in Australia, any selection for improved thermoregulatory efficiency across the latitudinal range could operate only on a pre-existing set of features (morphological and physiological) adapted to optimising survival in cold environments.

There are also the issues of time depth (how long a period of exposure to a particular thermal environment is needed for any effects of selection to become apparent), intensity of exposure (whether more extreme environments elicit more rapid adaptations through more intense selection pressure), and the environmental range of the group (how great a range is required, e.g. in terms of latitudes or isotherms, for any trends to become discernible). Moreover, these factors are not necessarily independent. In the Australian case, while the environmental ranges are comparatively modest by continental standards (33° of latitude, including Tasmania, and 20°C range in mean annual temperatures during historical times), the time depth involved – at least 45,000 and perhaps 60,000 years for the mainland (Thorne *et al.* 1999, O'Connell and Allen 2004) and 35,000 years for Tasmania (Jones 1995, Cosgrove 1999) – suggests that some Aboriginal groups experienced cooler conditions for a sustained period during the late Pleistocene, notably in the southern regions and especially in Tasmania.

In addition to the time depth of their occupation of the continent and their consequent exposure to Pleistocene cooling, there are other reasons for anticipating a discernible thermal trend in Aboriginal morphology. First is the relative stability of their occupation, with Australia being generally less affected by the major movements and diffusions of populations (and their cultures, including clothing habits) that occurred across much of the globe towards the end of the last glaciation and throughout the Holocene. Second, it is possible that their "hypothermic" physiological response to cold may have placed a greater burden on morphological adaptation to cold exposure. Third, unlike some other fully modern human groups such as the indigenous Americans mentioned above, whose immediate forebears needed to survive in subpolar environments late in the Pleistocene, it can be argued (and this will not be elaborated here) that the Aborigines would have had little reason to develop any sophisticated "cultural" adaptations to cold (*viz.* fitted clothing) when they first entered the continent through the tropics, possibly at a time of lower sea levels during marine isotope stage 4 (MIS 4, c. 75-60,000 years ago). Their pre-existing habitual nakedness, in other words, could place more of a burden on morphological adaptation among the Australian Aborigines were they to subsequently experience episodic or prolonged cold exposure in the higher latitudes of southern Australia and Tasmania, particularly when thermal conditions deteriorated later in the Pleistocene towards the end of MIS stage 3 and during the glacial maximum in stage 2 (between c. 35,000 and 14,000 years ago).

**Birdsell's data**

Comprehensive metrical data on body form among mainland Aborigines are presented by Birdsell (1993). These data are interpreted by Birdsell in relation to his "trihybrid" theory of Aboriginal origins (Birdsell 1967). However, the indices that relate to body form are amenable to an alternative analysis which looks at morphological variation in relation to thermal gradients across the continent. Of most relevance here are the data on body shape and limb proportions, although other metrical and non-metrical features (e.g. cranial and nasal measures, skin pigmentation, and hair form) might also benefit from further analysis, given that variations in such features have been cited elsewhere as examples of environmental adaptations in other human groups.

Looking first at body shape for mainland Aborigines, Birdsell provides data for two measures. First is the ponderal index, obtained by dividing stature (height) by the cube root of weight. High values for the ponderal index reflect a more linear build while low values indicate a relatively stocky build. The "clinal topography" of this index shows that even though the range of values is not great, "with few exceptions, the index is low in the southern two-thirds of the continent and high in the northern one-third" (Birdsell 1993: 313). Most of the few exceptions, according to Birdsell, probably reflect population changes in historical times.

The second measure of body shape is relative shoulder breadth (shoulder breadth divided by height), where the clinal topography shows an even clearer north-south gradient. Birdsell prefers to interpret this by alluding to multiple waves of immigration by morphologically divergent peoples in the past, although at one point he does give consideration, albeit briefly, to possible thermoregulatory aspects (ibid: 316).

The other salient metrical measures in Birdsell's analysis relate to limb proportions: relative sitting height, radial-

humeral index, tibial-femoral index, intermembral index, humeral-sitting height index, radial-sitting height index, femoral-sitting height index, and tibial-sitting height index. While some of these are of more direct relevance here than others, they all show clinal distributions that should correlate well with thermal gradients, especially when factors such as desert extremes and the ameliorating effects of coastal proximity (and humidity) are taken into account.

Overall, these data on body form and limb proportions are not inconsistent with what is to be expected in terms of thermal adaptations in morphology for the mainland Aborigines. There is a marked trend towards a less linear body shape in southern regions and, similarly, a reduction in relative limb proportions (including distal to proximal limb segments) in southern regions. The magnitude of variation is not great, and the mainland Aborigines in general maintain an essentially tropical morphology throughout the continent. The trends are there, nonetheless, and it would be unexpected if these same trends (toward a more lateral build and reduced limb proportions with increasing latitude) did not extend to Tasmania.

**Tasmanian Aborigines**

It would be superfluous here to become involved in any debate about Aboriginal origins, since the reasons for the clinal topography in body form identified by Birdsell are, perhaps surprisingly, not necessarily relevant in this context. What does matter is the existence of the clinal variation, and competing factors of population dynamics and thermoregulatory influences need not be mutually exclusive.

However, the issue of Aboriginal homogeneity could have some bearing on the question of cold tolerance (and hence relative clothing needs) among the Tasmanian Aborigines. If the clinal topography in body shape is more a reflection of “microevolutionary” than environmental influences, it may complicate any hypothesised extension of these morphological trends from the mainland to the Tasmanian Aborigines. This could be problematical given that reliable data of the quality presented by Birdsell for the mainland Aborigines are sorely lacking for the Tasmanian Aborigines and assessments of the relevant morphological features depend largely on historical descriptions and depictions.

Analyses using craniometric data have failed to align the Tasmanian Aborigines with their supposed Negrito relations, leading William Howells to declare that “the notion of a Negrito element in the Tasmanians should be laid to rest” (Howells 1973: 125). Without resurrecting the debate, it can be remarked here that the fact that the Tasmanians showed some distinctive physical features is beyond dispute, but so too is the fact that they existed in some degree of isolation from the mainland for a prolonged period, in thermal environments (past and recent) where natural selection for at least some modification of their tropical Aboriginal morphology would not be unexpected. It may be noted that some other features, such as a less elongated (or less dolichocephalic) head shape and altered skin pigmentation, hair form and nasal structure may, to some extent, reflect a combined effect of environmental influences (e.g. Coon 1965, Harrison1975) and comparatively prolonged isolation.

The close relationship between Tasmanian and mainland Aborigines is readily apparent in Pardoe’s (1994) study of non-metric cranial data, wherein the Tasmanians showed somewhat less divergence from the mainland Aborigines than would be expected given the period of isolation. Along with other studies using both metric and non-metric cranial data (reviewed in Pardoe 1994), not only are the Tasmanians grouped best with the mainland Aborigines, but the trends in cranial size and shape tend to suggest a “correlation with latitude” for which one possible interpretation is a “clinal variation in head shape along an environmental gradient” (ibid: 3).

The time depth required for morphological adjustments to varying thermal environments is not established, although it would seem that comparatively short periods (in prehistoric terms) of sufficient exposure to cold can exert a significant selection effect at the genetic level. Animal studies have shown changes in body shape along the lines of Bergmann’s and Allen’s rules and other changes such as increased body hair and skin vascularity, even within the first generation (e.g. Fuller 1965: 542, Ingram and Weaver 1969: 522), suggesting that environmental exposure during early growth can exert a significant influence on phenotype, if not genotype (Harrison *et al.* 1964: 460). For genetic influences on body form to become established in human populations Ruff (1994) suggests 20,000 years is more than adequate, given that the recent distributions of these trends in body shape and limb proportions follow thermal gradients among indigenous populations. There is some evidence that shorter periods of cold exposure may have a noticeable influence, especially in relation to relative limb proportions (Jacobs 1985).

In addition, the use or absence of clothing (particularly fitted garments) is likely to have some effect. For example, the fully modern humans who entered Europe and central Eurasia towards the end of the Pleistocene managed to preserve their tropical limb proportions despite the extremely cold conditions. This may well reflect their use of sophisticated tailored garments, as illustrated for instance by the burials at Sungir (Bader 1964, 1970). Such garments provided effective thermal protection for their limbs, allowing a relaxation of selection pressure for reduced limb proportions. Neanderthals, on the other hand, are likely to have managed, up to that time at least, with simple draped cloaks that left their limbs more exposed. This would have maintained selection pressure for morphological adaptation (i.e. reduced limb proportions), which in turn would lessen their need for more sophisticated “cultural” adaptations in the form of complex clothing. Strictly speaking, the maintenance of more tropical limb proportions in high latitudes among some early fully modern human groups by virtue of their clothing does not contradict Allen’s rule. The latter will apply more to exposed portions of the body, and the limbs of those wearing fitted garments (such as cloaks or

shirts with sleeves to cover the upper limbs and trousers that enclose the lower limbs) are less exposed to the cold. Garments fitted to cover the limbs were not evident in Aboriginal Australia, and only loose-fitting, single-layered garments are documented, so any use of clothing would be expected to have little influence on Aboriginal morphology.

**Tasmanian morphology and the clothing paradox**

The foregoing points to the likely role of thermal and other environmental factors as an influence on the observed geographical variation in certain aspects of Aboriginal morphology. This has implications for clothing use among the mainland and Tasmanian Aborigines, for three reasons. First, it becomes more plausible to infer an extension of these trends from the mainland to Tasmania, compensating in part the dearth of relevant physical anthropological data (especially post-cranial measures) for the Tasmanians. Second, if, during the late Pleistocene, thermal conditions exceeded the physiological limits of cold tolerance despite these morphological adaptations, such conditions are likely to have an influence on the use and further development of "cultural" adaptations. As a result, the Tasmanian Aborigines may have needed more clothing in the Pleistocene than in the Holocene. Third, if the Tasmanians can be shown to exhibit greater morphological adaptation to cold than mainland Aborigines in the southern regions, this may help to explain their comparatively greater "nakedness" at the time of early European contact.

It should be feasible, therefore, to approach the Tasmanian clothing paradox by looking at how thermal conditions varied both in space (viz. latitude, altitude, and topography, e.g. the availability of natural shelter) and in time (viz. the late Pleistocene and the Holocene), and how this variation may have influenced human morphological and cultural adaptations. These variables are not independent of each other, and it is an appreciation of their likely interaction that may facilitate a resolution of the paradox. It may be the case, for instance, that Holocene conditions on the southern mainland required more substantial clothing among the mainland Aborigines, because they had developed less morphological cold adaptations than the Tasmanians. On the other hand, late Pleistocene conditions in Tasmania could have resulted in more intense selection pressure for both morphological and cultural adaptations, with greater development of the former allowing a comparative relaxation of the latter in the Holocene.

For these reasons, the extent of morphological adaptation to cold among the Tasmanian Aborigines assumes considerable significance. Indeed, many of the physical characteristics that distinguished full-blood Tasmanians from the mainland Aborigines are cited in the physical anthropology literature in the context of possible thermal adaptations. This applies not only to body shape and limb proportions, as reviewed above, but to a host of other features. Insofar as the Tasmanians exhibit some of these features, it may add further (if only indirect) weight to the argument that the Tasmanians of the "ethnographic present" were morphologically more suited to coping with cold than were their mainland counterparts.

# Chapter 4 Rationale

The problem of the Tasmanians' unexpectedly reduced use of clothing (compared to their mainland neighbours, and despite the higher latitude), and the extent to which the predicted thermal pattern of Aboriginal clothing use in general can be tested using the ethnographic record, may be addressed in the following fashion:

First, does the observed pattern of Aboriginal clothing use on the mainland really conform to what could be predicted solely from environmental and physiological sciences?

Second, how real is the clothing problem of the Tasmanians?

Third, if the Tasmanian clothing problem is real, does it constitute a refutation of the thermal model, or can it be accommodated?

The Tasmanian clothing paradox raises important issues, of both a local (Australian) and a wider (theoretical) nature. Given the limitations of space, the aim here is to primarily address the local issues, and, where possible, to at least hint at some of the wider issues, in a logical and coherent manner.

## Local Context

Jones' "Tasmanian Paradox" drew attention to the interpretive challenges posed by the comparative simplicity of the Tasmanian Aborigines' existence, as indicated, in his opinion, by both the ethnographic and the archaeological records. While many aspects of his argument have been strongly criticised if not discounted, his fundamental point remains essentially intact. This is, that their cultural repertoire was in most respects simpler than that of their contemporaries on the Australian mainland but, nonetheless, it was apparently no less efficient or effective in a functional or an adaptive sense.

The clothing paradox embodies all of the elements and problems highlighted by Jones, but, as with the treatment of clothing generally in anthropology, it has attracted little systematic investigation. In revisiting Jones' paradox by focusing on the clothing issue, it may be demonstrated that by utilising available data from those disciplines which can contribute relevant material, the problems posed by the clothing paradox can be addressed productively. Moreover, this should be possible without resort to the kind of post hoc accommodative argument of Jones, which tends to explain away, rather than explain, the substantive problems posed by the evidence.

## Wider Context

The use of clothing plays a range of non-thermal functions in complex societies, wherein some of its psychosocial, economic and cultural functions often exert more influence on its use than any thermal considerations. In the Australian Aboriginal context, however, thermal considerations alone may be sufficient to account for the ethnographic evidence as to its patterns of use. To ascertain the extent to which this proposition is defensible is one of the broader aims of this work. This, it will be posited, necessarily has implications for one of the long-standing conundrums in cultural anthropology, the question of the origins of clothing.

The Tasmanian clothing paradox represents, at face value, a potential refutation of this thermal model of clothing use in less complex social environments. Indeed, insofar as the Tasmanian cultural milieu has been conceptualised by some as less complex than any on the Australian mainland (for whatever reasons), reduced use of clothing in Tasmania despite the higher latitude could be cited as suggesting a role for social as opposed to thermal functions, even in the Australian context. On the other hand, and without making any assumptions as to the relative cultural complexity of Tasmanian and mainland Australian Aboriginal societies, a careful consideration of all the relevant thermal physiological factors could demonstrate that the paradox is explicable by reference to thermal principles. If so, the paradox would fail as a refutation, and, as such, this failure would constitute a corroboration of the thermal model.

By exploring the Tasmanian clothing paradox in some depth, it is implied that the whole subject of clothing can prove of more relevance than is generally appreciated. Or, at least, that it warrants more attention than has generally been the case. In making this claim, it will be argued that it is in the archaeological domain that this attention would be especially pertinent. Jones, for instance, wondered about the possible significance of clothing issues for one of the key archaeological aspects of his paradox, namely the disappearance of bone tools from the Tasmanian archaeological record in the early- to mid-Holocene. Moreover, he alluded to the likely role of thermal physiological issues, and specifically human requirements for adequate shelter and clothing in periglacial environments, as important issues to be explored in the late Pleistocene archaeological record of the island. Specifically, there is the utilisation of caves, the advent of bone tools and so-called thumbnail scrapers, and the apparent targeting of certain marsupial species by humans. These are the key features that distinguish the late Pleistocene and Holocene records, and for Jones they not only demanded explanation in themselves, or within local and regional contexts. In a wider context, their comparability with late Pleistocene trends at similar latitudes in the northern hemisphere was intriguing. Interpretation of the late Pleistocene Tasmanian archaeological record, in other words, is not only a challenge in itself. It should allow for, and indeed it invites, precisely the kind of intercontinental comparisons that can be most useful in testing general models of human prehistoric technological innovation and cultural development.

## Strategy: three studies

The strategy adopted to examine the Tasmanian clothing paradox, and to broach the wider issues, is to employ three distinct research studies. Such a strategy is dictated by the multi-faceted nature of the problems raised by the paradox, which cannot be properly addressed in isolation from the different domains upon which they encroach. The main focus is the ethnographic study (Chapters 5 and 6), since this is the primary evidence source for the paradox. A second study (Chapters 7 and 8) examines in detail the question of Aboriginal morphological variation from a thermal perspective, and its findings are specifically focused on implications for the clothing paradox. The third study (Chapters 9 and 10) tackles the challenge of applying thermal principles to the late Pleistocene archaeological record in Tasmania. The findings from each of these studies are summarised, and their limitations reviewed, in chapter 11. In Chapter 12, some of the local and wider issues are reconsidered in light of the findings.

### Ethnography

The major aim of the first study is establish, as far as the evidence permits, the reality or otherwise of the Tasmanian clothing paradox. It also aims to test to what extent the use of clothing in Aboriginal Australia can be understood in thermal terms, and whether any exceptions to this predicted pattern are evident. The methodology, detailed in the appropriate section of the study, involves categorising and quantifying the ethnographic evidence on clothing from the entire Australian region, including Tasmania, matching the ethnographic data with a number of meteorological measures, and then subjecting this data base to simple statistical analyses. The latter will explore the relationships between the ethnographic and environmental data, and test the extent to which the Tasmanian data lend support to the existence of the clothing paradox. Ethnographic data on morphological variation and the use of shelter are also included, although the ethnographic data on these topics, being subject to separate analyses in the second and third studies, are only examined descriptively.

### Morphology

The second study examines, first, the evidence for morphological thermal adaptations in the Australian Aboriginal population and, second, the evidence for additional thermal adaptations in the Tasmanian Aboriginal population that may be of particular relevance to the clothing paradox. Two analyses are undertaken, the first utilising Birdsell's data, which was collected from continent-wide tribal samples but includes very little on the Tasmanian Aborigines. This data base comprises Birdsell's data matched to meteorological data, which is then subject to statistical analyses to test for thermal relationships. The latter comprise correlation coefficients between each of the morphological variables and a range of environmental indices, including temperatures, insolation, humidity, rainfall, and wind chill, together with factor analyses on the morphological variables of special interest in terms of thermal adaptations. The second analysis utilises osteological data on measures that are most strongly linked to thermal adaptations in the literature, and it includes the limited osteological data that are available on the Tasmanian Aborigines. The Birdsell re-analysis in itself constitutes a useful addition to the study of human thermal adaptations, as no other studies have used such extensive data to explore this issue among Australian Aborigines. Taken together, the Birdsell re-analysis and the osteological analysis should facilitate an assessment of the extent to which Aboriginal morphological variation could contribute to a thermal resolution of the Tasmanian clothing paradox.

### Prehistory

This study examines one aspect of the Tasmanian archaeological record from a thermal perspective, namely the utilisation of cave sites during the late Pleistocene in relation to estimated wind chill conditions and likely human cold tolerance limits. Given that shelter becomes crucial when wind chill temperatures exceed safe physiological limits, this study aims to assess whether these limits were approached in Tasmania. Palaeoenvironmental data are used to reconstruct LGM conditions, together with related factors such as the thermal repercussions of reduced vegetation cover and the magnitude of seasonal and regional variation in thermal conditions. Statistical analyses are applied to assess correlations between cave site occupation and temperature levels throughout the late Pleistocene. The role of wind chill is explored specifically by examining data on the aspect of the cave sites, as protection from the colder southwesterly winds in critical thermal conditions is predicted to result in a distribution of aspect data heavily skewed away from the southwest. The findings may show that, counter-intuitively, protection from wind chill could help to explain the otherwise surprising presence of humans at higher latitudes and altitudes during the LGM – and, it would appear, during the colder winter seasons. This archaeological pattern stands in marked contrast to the ethnographic situation in the late Holocene, when Tasmanian Aborigines generally avoided the rugged southwest and favoured the coastal areas in winter. This study is a preliminary application of thermal principles to the archaeological record, and the question of clothing requirements in late Pleistocene Tasmania would benefit from a similar approach. This would not only add another dimension to the clothing paradox, but would represent an important step towards making intercontinental comparisons, as outlined in the Discussion section.

# PART TWO: STUDIES

## STUDY 1: ETHNOGRAPHY

## Chapter 5 Introduction and Method

### Introduction

Most of the evidence for a Tasmanian clothing paradox is ethnographic although, as outlined earlier, there exists indirect evidence in the archaeological record which bears upon the problem, and this is considered in the prehistory section (Study 3). The ethnographic evidence derives from descriptions of the Tasmanian Aborigines by European observers prior to, and in the first few decades subsequent to, the establishment of the first British settlement in the Hobart area, in 1803. For mainland Australia, there are likewise records from direct contact situations between Europeans and the Aboriginal inhabitants. These can be divided into a pre-settlement period, prior to the arrival of the First Fleet at Sydney Cove in 1788, and a post-settlement period from 1788 onwards.

The pre-settlement records are of greater value than those from the post-settlement era, given how the presence of European clothing affected the behaviour of the indigenous people with respect to clothes. However such effects cannot be discounted in the pre-settlement periods, as visitors often gave items of clothing to the Aborigines, and encouraged them to don the garments. In addition, for the Aborigines, the clothing worn by Europeans was usually a focus of attention in these situations. In itself, this may have altered their behaviour at the time, and subsequently.

One objective in reviewing the ethnographic record is to gain an appreciation of the use of clothing by Australian Aborigines prior to any "contaminating" influence of European contact. This objective is, by definition, an impossibility, since the records are dependent upon such contact. Observer effect, in other words, is a problem. Neither can it be assumed that the use of clothing among Aboriginal people even prior to European contact was free of external influences. There may, for instance, be evidence suggesting a pre-European effect in some regions, notably in parts of northern Australia.

Another problem is that all the documented pre-settlement contacts occurred along the coastal margins and, in the Tasmanian case (with one exception), were confined to the southeastern coastal region. This has two implications. First, climatic conditions along the coastal margins are generally subject to less extreme temperatures, due mainly to the ameliorating effects of oceanic air masses. Coastal margins are also at lower altitude, contributing to higher minimum temperatures. Insofar as local thermal conditions influenced Aboriginal use of clothing, the pre-settlement records will provide a limited sample in terms of the range of thermal conditions, and hence will bias the sampling of thermally-related Aboriginal clothing use. Second, it was only in the post-settlement periods that Europeans began to venture inland, so all the non-coastal contact situations occurred at times when the Aboriginal population was subject to increasing influences from the European colonial presence. As a consequence, any reports suggesting greater use of clothing among inland as opposed to coastal Aboriginal groups might be attributable either to thermal factors, or non-thermal regional variations in patterns of clothing use within the indigenous populations, or to effects of the European presence – or to any combination of these factors.

With these caveats in mind, the first-hand observations will be examined systematically. The methodology adopted for extracting and categorising the data for the quantitative analyses is presented. below.

In brief, the early pre-settlement descriptions by Europeans are almost unanimous in emphasizing the habitual lack of clothes, or the nakedness, among Australian Aborigines, both on the mainland and in Tasmania. There is an occasional mention of grass skirts or pubic coverings among women in northern Australia, and of wallaby-skin capes, again mainly among women, in Tasmania. Reports of more substantial garments on the mainland, namely kangaroo-skin capes and rugs, and opossum-fur cloaks and blankets, occur with increasing frequency in the ethnohistorical record as European settlers began to explore inland areas, especially in the southeastern areas of the continent, during the nineteenth centurey.

This study uses a quantitative approach to analyse the ethnographic data on Aboriginal clothing (and, to a lesser extent, morphological variation bearing on thermal adaptation, and the use of artificial shelter). In principle, the procedure follows that adopted by Hiatt in her examination of regional and seasonal variation in food items utilised by Tasmanian Aborigines (Hiatt 1967). In that study, she extracted and categorised data from the ethnographic records, which were then assembled in frequency tables to allow a quantitative analysis that could test a number of hypotheses. This method, she noted, while in some respects "crude", was "better than the unsupported statements that have hitherto appeared in the literature" (ibid: 102).

The method employed here entails first categorising the reports as denoting either presence or absence of clothes, and assembling these coded reports according to both the time of observation (year and season) and the location (e.g. latitude). Each of these coded reports can then be matched with local meteorological data, such as mean monthly temperatures. This allows the frequency of "naked" and "clothed" observations, for instance, to be examined in relation to temporal trends, geographical patterning, and thermal indices.

The data set is amenable also to simple statistical analysis, which can test whether any trends or patterning may be statistically significant. In particular, it allows for more formal testing of specific hypotheses as to Aboriginal use of clothing. In the present context, the main hypotheses concern the extent of thermal patterning in the results, and whether or not the data for Tasmania conform to any mainland trends.

## Aims

The main aim of the ethnographic study is to assemble a data base for assessing and interpreting the Tasmanian clothing paradox.

The study has, therefore, two subsidiary aims. First, to establish the extent and nature of the use of clothing in Aboriginal Australia, independent of European and colonial influences. Second, to examine any major trends or patterning in clothing use, and particularly to establish the strength of any associations with thermal characteristics of the Australian environment.

Additionally, ethnographic data have been gathered on two related topics, viz. aspects of Aboriginal morphology relevant to thermal physiology, and use of artificial shelters. However, since the data are limited to that encountered in the collection of clothing data, these two topics are treated in detail in the morphological study (Chapters 7 and 8) and the prehistory study (Chapters 9 and 10).

## Materials

Materials utilised comprise:

1. ethnographic records, and

2. meteorological records.

Data from the ethnographic observations, together with meteorological data for each case, were recorded on a form designed for this purpose (see below). Statistical analyses were performed using a fully licensed version of SPSS® Graduate Pack 11.0 for Windows®.

### Ethnographic records

The records utilised in the data base comprise recorded first-hand observations of Aboriginal people during the pre-colonial and early post-colonial periods. For reasons related to the scale of research, these were necessarily restricted to those available in published form. The available sources comprise both written and pictorial records.

*Written*

Technically, most of the first-hand reports are more correctly termed "ethnohistorical" rather than "ethnographic", as they were made prior to the emergence of ethnography as a formal branch of anthropology – indeed, either before the latter itself had emerged, or in the early days of its existence. The majority of the reports, while they may be used for ethnographic purposes, were prepared as historical records rather than ethnological descriptions. As a result, they do not adhere to any prescribed format. For this reason, among others, the context of each report should be considered, and some information on this can be gleaned from the details contained in the ethnographic section of the Appendix (Appendix A1).

As mentioned in the "Definitions" section, while the use of terms such as "clothed" and "naked" is necessary in this study, it is attached with numerous problems. Nonetheless, for purposes of quantitative analysis, it has been necessary to categorize early European and colonial-era descriptions of the appearance of Aboriginal people as either "clothed" or "naked". This simple bipolar categorisation is selected in preference to more complex rating scales, such as a modified Likert scale, which would only introduce more complexities without removing the inherently subjective elements. The major area of ambiguity is between items that can be termed "clothing" and those that better qualify as "decoration" or "ornamentation". The approach adopted here has been to adhere where feasible to the definition in the Concise Oxford Dictionary (2006), which stipulates or implies that the primary *intention* of clothing is to cover rather than decorate the body. Where no decision can reasonably be made, an "ambiguous" category is employed, but these reports are not included in the analyses.

The term "naked" has numerous problems, and only one example will be mentioned at this point. For the early European visitors and settlers, an important aspect of whether a person was naked or not was whether or not the genitalia were covered, and also sometimes, in the case of females, whether or not the breasts were covered. These difficulties arise in part because of the special sensibilities that surrounded the use of clothing by Europeans at the time (sensibilities that still pertain, of course). In short, the Europeans wore clothes for a multitude of reasons in addition to thermal needs, including physical modesty, along with various other psychosocial motives and purposes. This meant that, to some extent, a person might be described as "naked" if their attire was insufficient to preserve modesty or a sense of deceny, particularly in the Judeo-Christian sense, and especially if the genitalia were not covered adequately. This could result, for instance, in Aborigines being described as "naked", or even "fully naked" or "stark naked", when in reality they may have used, at least occasionally, simple animal skins or cloaks thrown loosely over the shoulders. If their genitals were left exposed to view, they might nevertheless be described as being "naked" by the Europeans. As a consequence, descriptions can vary, or appear inconsistent, even within the one account.

Another aspect, as mentioned earlier, is the possible influence of the mere presence of fully-clothed visitors on Aboriginal behaviour with respect to clothing. While most

of the earliest accounts involving interaction between Aborigines and visitors indicate a lack of interest by the former in donning any apparel (on the contrary, they often seemed more preoccupied in attempts to remove the visitor's garments or, failing that, their buttons), such an influence cannot be discounted. It certainly becomes an issue later, from the time of the first European settlements. Aboriginal nakedness became subject to sanction, and measures were taken that encouraged Aborigines to wear clothes. Such influences may have extended beyond the immediate environs of the settlements, and even beyond those who came into personal contact with explorers and white graziers. The accounts need to be treated with increasing caution from 1788, if not earlier. This creates a problem, as there is a dearth of accounts for the Aborigines inhabiting the southeastern corner, and the interior, of the continent that pre-date 1788.

Matters are made more complex by the likelihood that Aboriginal clothing use, where it did occur, was more sporadic than habitual. The length of time spent by the European visitors in contact with the Aborigines becomes relevant, as does also the time of year and season, if thermal considerations were indeed paramount. Especially with regards to the southern regions, the Europeans themselves were generally inclined to organise their voyages so as to make landfall in the warmer months when maritime conditions were less dangerous. This could result in observations being biased towards times of year when the Aborigines had less thermal need for protection, leading to underestimates of clothing use.

With regard to morphological variation, given its possible key role in the Tasmanian clothing paradox, ethnographic descriptions of mainland and Tasmanian Aboriginal body form are considered. However the available material is meagre on this issue. There is no possibility of making metrical comparisons because only a few measurements were ever recorded for the Tasmanians, and these are not useful here. On the D'Entrecasteaux visit in 1793, body measurements were taken on some of the "most robust" individuals:

> *We measured the most robust of those who were heads of household and found —*

| | |
|---|---|
| *Length of forearm, with the hand* | *16 inches* |
| *Breadth of the shoulders* | *16 inches* |
| *Height of the head* | *10 inches* |
| *Thigh* | *18 inches* |
| *Leg* | *18 inches* |
| *Foot* | *9½ inches* |
| *Length of the head* | *7 inches* |
| *Width of the mouth* | *3 inches* |

(Raoul, in Plomley and Piard-Bernier 1993: 306)

Reliance must therefore be placed upon written descriptions, with all their attendant ambiguities. That the mainland Aborigines were of a linear build may be clear enough, although there is still the question of whether there was any trend towards a more "lateral" build in southern regions, conforming to Bergmann's rule. For the Tasmanians, there are even greater problems, as the early contact reports show a wide disparity in their descriptive terms. The key summary is found in Roth (1899). Another major contribution is that of Plomley, whose 1983 account of the Baudin expedition includes summations of Tasmanian clothing and morphology.

Problems of definition occur with descriptions of Aboriginal morphology. These are categorised, where possible, as indicating either a more "linear" or "stocky" body build. Again, a bipolar scale is utilised, facilitating the use of simple statistical tests. Most problems arise with applying the term "stocky". Aside from being confounded with height or stature, the descriptors often refer to muscular development in ways that might otherwise suggest "stockiness", which in the context of this work is intended to refer more to overall shape and limb proportions. However, the ethnographic descriptions of body build are incorporated in this work only as an adjunct to the metrical indices used in the morphology section (Study 2), so the ambiguities should be of less concern, whereas the clothing study is entirely dependent upon ethnographic records. Even so, a paucity of metrical data on Tasmanian Aborigines leads to some reliance upon these ethnographic descriptions of body build for the Tasmanian Aborigines. The original descriptions from which the "linear" vs. "stocky" ascriptions have been extracted can be found in the ethnographic data sheets in Appendix A1.

*Pictorial*

Pictorial records relating to Aboriginal clothing use and morphology could be used to supplement the written accounts, and also to illustrate some of the difficulties involved. The primary pre-settlement sources are, for the mainland, the artists on Cook's first voyage (including Parkinson) and, for Tasmania, the artists on Cook's third voyage (mainly Webber), and on the Baudin expedition (Lesueur and Petit). Artistic depictions from the early post-settlement period include drawings from the voyages of Matthew Flinders (artist Westall) and from Joseph Lycett, among others, including the unknown "Port Jackson Painter". The challenges confronting eighteenth and nineteenth century artists in depicting Aboriginal "nakedness" for a European or colonial audience were sometimes insurmountable. The temptation for publishers to satisfy public curiosity by using inaccurate if not fanciful illustrations to accompany the written accounts was all too often irresistible, as shown by convict George Barrington's reminiscences (Barrington 1795). Also, there are nineteenth century photographs of Aborigines (e.g. Massola 1971), particularly relevant to European influences on the Aborigines and their portrayal by the colonists. For instance, a circa 1858 photograph (photographer unknown) depicts Aborigines in the upper Yarra River area, southeastern Australia (ibid: 14). All appear well-clad, with some wearing opossum-skin cloaks and the remainder covered with European-style blankets.

The pictorial records are not subjected to systematic analysis in this study, for a number of reasons. Aside from presenting

their own inherent ambiguities and challenges for interpretation, analysis of such records constitutes a whole theoretical domain in itself. As such, it is beyond the scope of the present study, belonging more to the province of art history. In this field, the work of Bernard Smith on Cook's Pacific voyages is a definitive contribution (Smith 1984, 1992). Smith for instance observes that the habitual nakedness of Australian Aborigines presented certain problems for the Europeans depicting them. At Endeavour River in the winter of 1770, Parkinson sketched an Aboriginal man posing in a garment given to him by the visitors, and in other drawings by Parkinson the genitals are often indistinct. There is, Smith remarks, "an element of prudery in Parkinson's sketches", suggesting "a reluctance to show his subject in a state of total nudity" (Smith 1992: 96). A little less prudery is sometimes evident in the depictions by early French visitors (e.g. Bonnemains *et al.* 1988: 137-180).

In discussing the ethnographic data derived from the written records, occasional reference may be made to particular illustrations where relevant, but otherwise the pictorial record will not be examined. Depictions of Aborigines at Port Jackson in the first few years of the colony, for example, indicate simply that "clothing was not normally worn" (Lampert 1988: 23). It is doubtful whether much additional information pertaining to the aims of the study would be collected by examining the pictorial record. Historian John Gascoigne has commented, in relation to first-hand observations of Aboriginal nakedness by Europeans, that these may be considered "reliable", especially as the records "describe a situation which generally ran counter to their natural assumptions and the written and pictorial records are in harmony" (Gascoigne, pers. comm.).

### *Anthropological accounts*

Aside from the first-contact accounts, there are secondary sources that constitute early anthropological syntheses. They are of varying quality and reliability, in part because their primary sources for information about Aboriginal behaviour are not always made explicit. Furthermore, they often fail to make adequate allowance for how rapidly and profoundly Aboriginal behaviour had begun to change as a result of the European presence.

For clothing use on the mainland, the major early works include those of Dawson, Brough Smyth (Smyth 1878), Bonwick, and Howitt. Each of these deals mainly with the region of most interest here, namely the southeast mainland including what is now Victoria, where first-contact reports are rare and pre-settlement (i.e. pre-1788) descriptions nonexistent. Dawson's (1881) volume on the western district tribes of Victoria, for example, has been shown to have limitations and inaccuracies. He devoted a small chapter to their clothing, which he summarises as consisting of a short "apron" made from strips of opossum skin for the men, with a kangaroo skin added as a cloak in winter, and an opossum rug worn "at all times" by the women which doubled as a blanket at night. The women, he said, also wore a girdle of emu feathers round the loins. This use of loin coverings by both sexes may be suggestive of a European influence, but the manufacture and use of marsupial skins as cloaks does carry a ring of authenticity, and stands in contrast with the total absence of any such apparel documented on Cook's voyage along the eastern coastline in 1770. With the Tasmanian Aborigines, the first true anthropological work was Roth (1899). Roth's review of the Tasmanian's minimal clothing is extensive, and may suggest that a European influence is discernible from the outset, although he does not spell this out. He does note, however, the total absence of physical modesty, and the Tasmanians' aversion to European garments, which they discarded at the earliest opportunity.

Twentieth-century anthropologists have generally had less to say on the subject of the Aborigines' pre-colonial predilection to dispense with clothing where possible. Textbooks of Australian prehistory, for instance, generally have little or nothing to say on the subject (e.g. White and O'Connell 1982, Lourandos 1997, Mulvaney and Kamminga 1999). Mulvaney's *Prehistory of Australia* (1975, revised edition) is an exception. It provides a reasonable consensus opinion, namely that the use of cloaks and rugs made from marsupial skins was confined to the southern regions of the mainland as a reflection of thermal requirements (cf. Kamminga 1982: 38), although Mulvaney does not discuss the difficulty of the Tasmanians' greater nakedness. A few papers have specifically looked at Aboriginal skin cloaks and rugs (Mountford 1960, 1963, Wright 1979), particularly with regard to their method of manufacture and their evident distribution along an essentially thermal geographical gradient on the mainland. These papers provide a wealth of technical information, probably all there is to know, or at least all that can now be known, on methods of manufacture and manner of use. Another paper to be considered is Reece (1967), on the dispensing of European clothing and blankets to the Aborigines in the early days of white settlement. This policy was intended to appease and also to help "civilise" the Aborigines, and probably resulted in a greater need for clothing. Yet, along with other factors such as a decline in marsupial populations as sheep grazing expanded, it may have led paradoxically to a reduction in the manufacture of cloaks and rugs from marsupial skins. Examples of more recent works which discuss Aboriginal clothing include Turbet (2001: 12-13) and Attenbrow (2002: 107).

## The data base

### *Clothing*

Two categories are used, viz. "naked" and "clothes" (Figure 1). To allow for a number of possible permutations, each of these categories is coded as either "affirmative" or "negative". A third category, used where necessary, is "ambiguous". The two main categories are not mutually exclusive, and a particular observation may be coded as affirmative in both. For example, with a specific observation, a number of individual Aboriginal persons might be described, some as

being unambiguously "naked" while others may have items that can be classed as clothing. In other cases, a statement may be given in the negative, such as, for instance, "they were not completely naked", or "no clothing was seen on any of them". These are generally recorded as negative in the category denoted, and affirmative in the opposing category, although some descriptions are too ambiguous to allow for the latter. In addition to the overall coding, as "naked" and/or "clothed", each of these two categories has a subdivision for males and females, which might or might not be used depending on whether gender is specified. Often, gender-neutral terms such as "natives" or "blacks" occur. Unless otherwise indicated by context, these are coded as applying to males, as the presence of females was usually noted by the observer. The advantage of coding in both "naked" and "clothed" categories for each description is that this allows for them being not always mutually exclusive, and so these two main categories can be analysed separately. They may be expected to show inverse trends, but one or other category may show more marked trends, or reveal more disconformity with respect to Tasmania.

For settlement-era accounts, the same coding procedure is used. In terms of locating first-hand observations, most attention has been given to the first few decades following the establishment of the first settlements (1788 for the mainland, 1803 for Tasmania). In the case of Tasmania, the first few decades cover all or nearly all of the available accounts, with only one being found for Oyster Cove, where all the remaining full-blood Tasmanian Aborigines were located from October 1847 onwards. There were rumours that one or two individuals had managed to evade the earlier re-location to Flinders Island, but none of these stories were substantiated. For the mainland, given the ever-increasing and expanding European influence, there is the problem of reduced reliability, even of first-hand descriptions, as to their utility for inferring pre-contact Aboriginal behaviour. There are exceptions, however, and there were a number of expeditions into the interior and to other regions where the spread of European influence was delayed, from which reasonably reliable descriptions might be gleaned. The expeditions of Giles (1889) and Carnegie (1898) across the central and western desert regions, for instance, should not be excluded or discounted because of their comparatively late dates (the 1870's and the 1890's respectively). A few records are even included

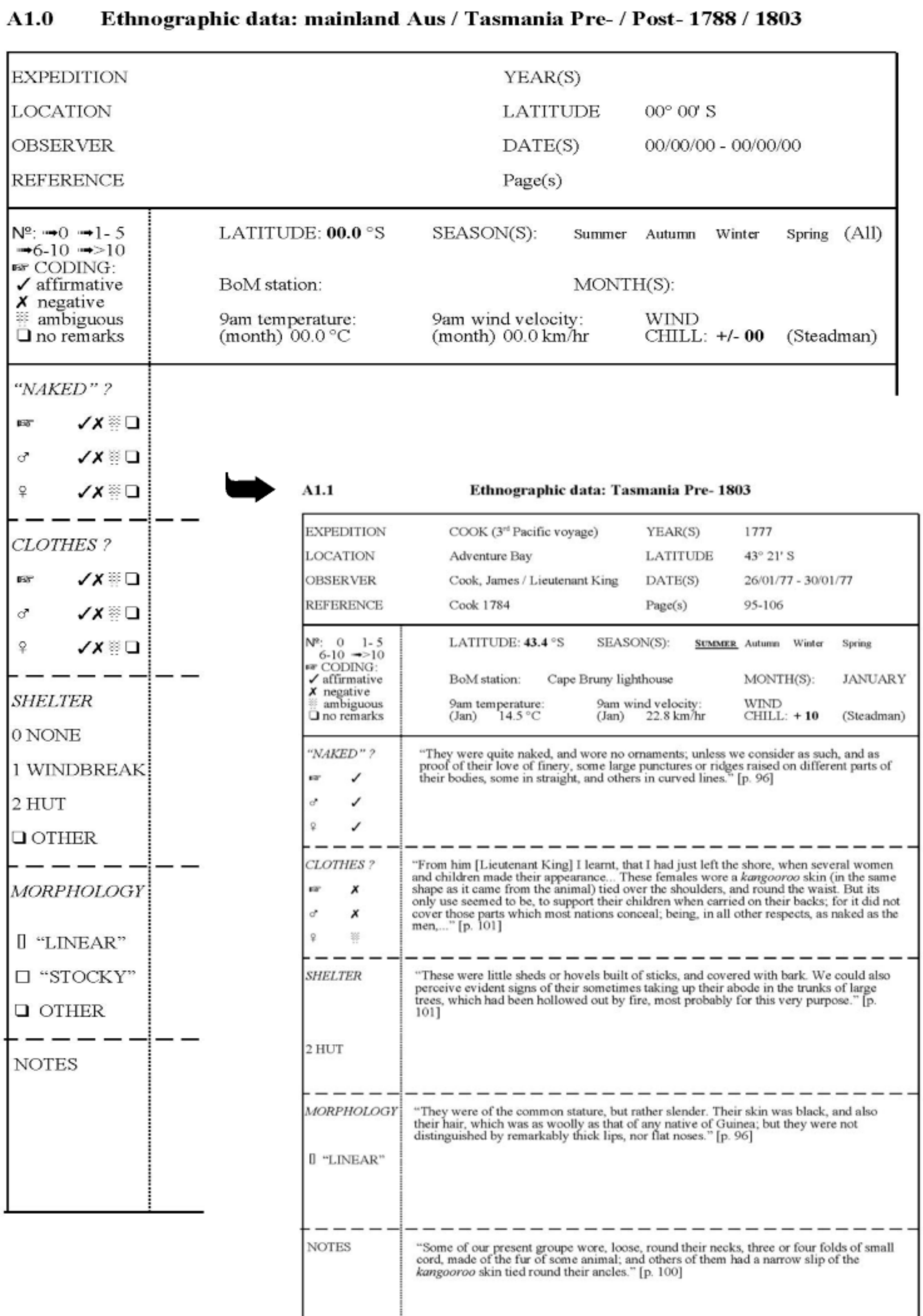



Figure 1 Template for ethnographic coding, and (inset) a sample completed data form

from the twentieth century, such as those of Bates (1944), though perhaps more for historical interest. The most recent accounts are those of Beadell (1965, 1976, 1983), who surveyed remote areas in central Australia while constructing access roads into the interior for the Woomera Rocket Range and the British atomic bomb tests (and who established one of Australia's most remote meteorological stations, named Giles, on the edge of the Gibson Desert). He encountered a number of individuals and tribal remnants who had apparently continued in some degree of isolation as late as the 1950's and 1960's. There is also the account of Peasley (1983), who searched for and found an Aboriginal couple reported to be still living in the Gibson Desert in the 1970's.

*Shelter*

While only a secondary aspect in this ethnographic clothing study, descriptions of artificial shelters constructed by Aborigines have been included and coded. However, these are generally limited to where such descriptions occur in direct association with the first-hand descriptions of Aboriginal clothing use. The actual number of such observations of shelters independent of clothing descriptions encountered during the ethnographic survey would run into thousands, and constitute a major study in itself. The shelter data should therefore be considered as extremely selective, and only very preliminary comments will be made.

Coding for artificial shelter is either "none", where a definite absence of any form of shelter is noted explicitly by the observers (in the context of a clothing description), "windbreak", or "hut". The distinction between these last two is whether protection is afforded only on one or more sides, without any kind of overhead protection, or whether some overhead protection is afforded . Many Aboriginal huts, for instance, comprised simply two or more upright sheets of bark leaning against each other, or a single piece of bark folded to form a kind of tent. Generally, windbreaks are described as such in the reports, while huts were denoted by various Aboriginal terms such as "whirlies", "gunyahs", and so on. A fourth code, "other", was used in the few instances where the description could not be coded as windbreak or hut or, as was more frequently the case, where there was no description of artificial shelter in direct association with the clothing description.

*Morphology*

The ethnographic record was examined also for reports of Aboriginal morphological variation. The Tasmanians were described in many of the first-hand accounts as being visibly distinct from their mainland counterparts, although the features most commonly cited, such as hair form, and skin colour or shade – while being a focus of attention, along with minor differences in cranial form, for an earlier generation of anthropologists – are of little or no interest in this context. Rather it is descriptions of body form, particularly those that may or may not indicate a stockier build for the Tasmanians, that are sought.

The earliest descriptions will be most reliable, as dietary and other lifestyle changes consequent upon contact with the British presence may affect Aboriginal body form. Coding is limited to overall body form, either "linear" or relatively "stocky". The latter, as discussed earlier, presents certain problems, especially as it is often conflated with stature, and also with visible muscular development, neither of which relate necessarily to relative body shape. Particular attention has been given to distinguishing these different meanings in each case, and to making an assignation to "stocky" only where the ambiguity is considered minimal. Nonetheless, the reliability of this category can be considered modest at best. A third code, "other", is included, where descriptions may appear contradictory – for instance, where some aspects of the description may suggest "linear" while others suggest "stocky" – or where descriptions of morphology occur that may have thermal significance but which are unrelated to body shape, for instance, skin colour, head hair form or abundance of body hair.

*Meteorology*

Aside from latitude, which is converted to digital form (e.g. 25°30' = 25.5°), and season, a number of meteorological indices are given for each observation. These are derived from data provided by the Australian Bureau of Meteorology for the station in closest proximity to the location of the observation (and for which wind velocity data are given). In most instances, a reasonable match can be made, although for some of the more remote locations, the nearest meteorological station may be 100km or more from the place of observation. The meteorological data do not apply specifically to the actual time of observation. Rather they comprise mean monthly (or, in some cases where the date(s) for the observation are poorly specified, annual) figures. Also, data have been collected for some stations over a period of many decades, sometimes a century or more, whereas in other cases they have has been collected over three or four decades. These data are nonetheless the best available and represent, by global standards, comprehensive data with good geographical coverage.

The main indices selected are mean monthly (or annual) 9am temperature (°C) and 9am wind speed (km/hr), from which monthly wind chill temperature is calculated. Further meteorological indices were added, comprising mean July 9am temperature, annual mean daily minimum temperature, and annual mean 9am wind speed. From these last two, an annualised "wind chill" figure using the annual mean daily minimum temperature was derived, to give an indication of overall windiness and minimum temperatures at each location.

Wind chill is calculated for each location from the monthly (or, where applicable, annual) temperature and wind velocity averages, using the Steadman formula. Calculations are performed using the wind chill calculator provided at the Netherland's Meteonet webite (Meteonet 2001). A number of wind chill calculators are available on the internet, but most accept only a limited range of air temperatures (e.g.

below 10°C), and also a limited number of measurement units (e.g. Fahrenheit only, or wind speed only in m.p.h.). The Meteonet site accepts a full range of temperatures (in Fahrenheit and Celsius), and wind speed in m.p.h., knots, m/s and km/hr. It also gives results using both the Siple and the Steadman formulas.

## Method

The data base, having been assembled as above, is used to examine the Tasmanian clothing paradox by testing a number of null hypotheses. The research design involves first examining the data for any major trends or patterning and then, where possible, subjecting any emergent trends to appropriate statistical testing. The basic prediction to be tested is that Aboriginal clothing use prior to white settlement followed thermal gradients, with, for instance, increased use corresponding approximately to increasing latitude. This trend should extend to Tasmania, where it would be predicted, other things being equal, that the Tasmanian Aborigines should have made at least as much use of clothes as any Aboriginal groups on the mainland, especially those in the southern regions. If Tasmania appears to meet this thermal prediction, it will suggest there is no clothing paradox. Conversely, if clothing use in Tasmania does not follow any mainland trend of increasing use with increasing latitude, existence of a Tasmanian clothing paradox is corroborated. The same considerations apply for the other thermal indices, which provide more precise (i.e. more physiologically relevant) indications of thermal conditions. Descriptions coded as "naked" represent an alternative measure of clothing use, and should show inverse trends to the "clothed" variable.

The shelter and morphology variables are likewise examined for overall trends, then, depending on the quality of the data obtained (e.g. sample size, geographical spread, and latitudinal range), will be represented in graphical form and subjected to statistical analyses where appropriate.

The data base is divided into Tasmanian and mainland sections, and each of these is subdivided into pre-settlement and settlement era sections. This allows the data to be examined both for the mainland alone, and mainland and Tasmania combined, and also separately for the periods before and after the beginning of white settlement. Separating the latter allows for an examination of the question as to whether there are any apparent effects of European colonisation, despite all the data ostensibly relating primarily to Aboriginal use of indigenous as opposed to European-style clothing.

**Null hypotheses**

These questions can be summarised as a series of null hypotheses as follows. Each takes the form of a formal proposition, which is open to testing and possible refutation by critical evaluation using data from the ethnographic record.

The hypotheses are:

1. that there is no significant correlation between
   a) thermal indices (e.g. latitude), and
   b) clothing use;

2. that there is no significant difference in the pattern of clothing use between
   a) mainland Australia, and
   b) Tasmania;

3. that there is no significant difference in first-hand reports of Aboriginal morphology ("linear" or "stocky" body shape) between
   a) mainland Australia, and
   b) Tasmania.

To the extent that these hypotheses are refuted, inferences may be drawn regarding the contributions of environmental and morphological factors to the observed patterns of Aboriginal use of clothing. Such inferences can be used to assess the thermal model of Aboriginal "nakedness" and, if results point to its existence, the clothing paradox of the Tasmanians.

**Data limitations and screening**

Reference needs to be made to the various limitations inherent in the data itself, and how these may limit or affect the interpretation of the results. Most of these have already been mentioned in relation to definitions and the coding of the data.

The data base is screened for adequate geographical and latitudinal spread, and for temporal coverage, by plotting number of cases (observations) against latitude, longitude, and time periods (e.g. decades). These distributions are to be taken into account in the discussion.

**Testing for temporal trends**

The data can be examined for temporal trends in clothing use by looking at frequencies of observations in relation to decades, and to the pre- settlement and settlement periods:

*Trends by decade*

As examining frequencies per year is impractical, given that there are no data for some years, and some (e.g. 1788 for instance) are over-represented, it is more useful to look at intervals of a decade. This is applicable only to the settlement-era periods, as there will be insufficient samples in the pre-settlement periods.

*Pre-settlement vs. settlement-era periods*

The relevant periods are:

| | |
|---|---|
| Tasmania | pre-1803 (pre-settlement) |
| | 1803 + (settlement-era) |
| Mainland | pre-1788 (pre-settlement) |
| | 1788 + (settlement-era) |

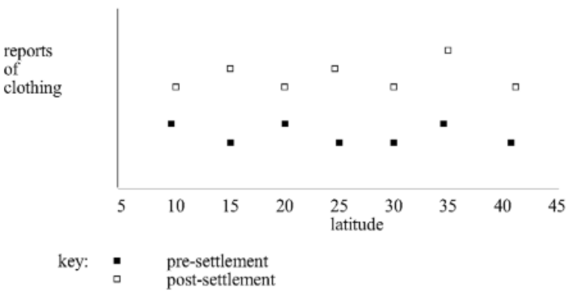
**Testing for thermal trends**

Thermal trends can be examined and tested by comparing the frequencies of reports coded as “naked” or “clothed”, and “linear” or “stocky”, against each of the thermal indices. For example, trends consistent with the first null hypothesis (that there is no significant correlation between thermal indices and clothing use) are shown in Figure 2. For morphology, results that would either corroborate or allow rejection of the third null hypothesis are shown in Figure 3.

In addition to latitude, results for both clothing/nakedness and morphology could be similarly presented in graphical form for the other thermal indices:

* season,
* mean monthly 9am temperature,
* mean winter (July) 9am temperature, and
* wind chill, based on the monthly average data for temperature and wind speed.

The anticipated outcome if use of clothing is not associated with latitude:




Results that may allow rejection of this null hypothesis could take the following form:

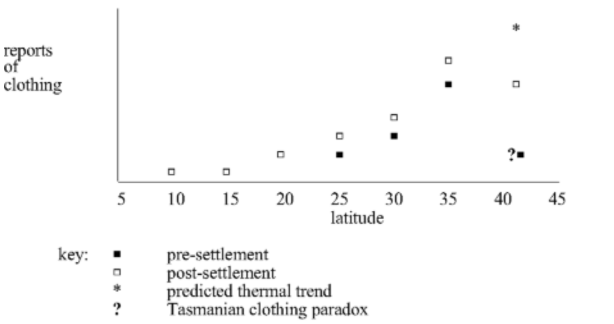



Figure 2 (above) Hypothetical trends for clothing consistent with corroboration (upper graph) or rejection (lower graph) of the null hypothesis

Figure 3 (right) Hypothetical trends for morphology consistent with corroboration (upper graph) or rejection (lower graph) of the null hypothesis

**Testing for disconformity in Tasmania**

To test whether the clothing and morphology trends for Tasmania do not differ significantly from those of the mainland, the results are examined by presenting the frequency distributions against latitude and, where applicable, the other thermal indices. In addition, it will be possible to perform statistical tests to assess the (statistical) significance of any differences. Given the categorical or “discrete” nature of the independent variables, the metrical or “continuous” dependent variables such as latitude can be categorised, facilitating the use of appropriate statistical testing. If the dependent variables were to remain as continuous, on the other hand, it would be difficult to test specifically for disconformity in Tasmania. For latitude, one strategy is to divide the whole latitudinal range into three categories, with Tasmania forming the third category on its own. The mainland could for instance be divided into two zones, with the latitude of Sydney forming a convenient boundary. The three zones would therefore comprise:

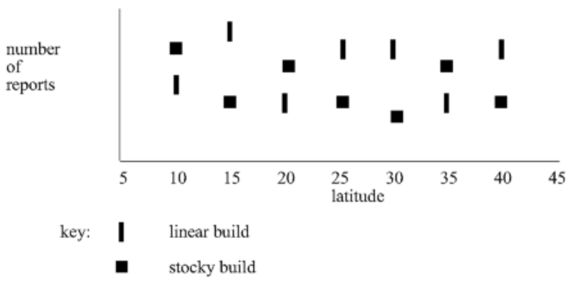
1. “low” latitude:
   < 34° S (Sydney region and northwards)

2. “medium” latitude:
   34 - 40 ° S (between Sydney and Bass Strait)

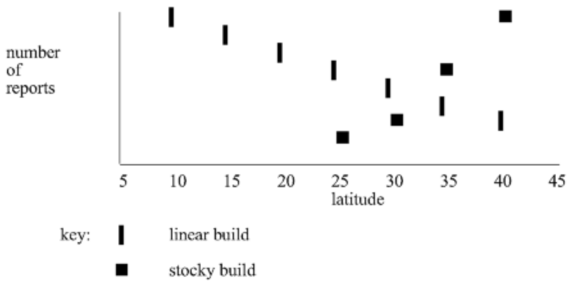
3. “high” latitude:
   > 40 ° S (Tasmania)

An alternative, and less arbitrary, approach is to generate latitude zones based on percentile groupings calculated from the latitudinal distribution of the ethnographic reports.

For morphology, the following results would corroborate the third null hypothesis:




Results that may refute this null hypothesis could appear as follows:



This takes into account the uneven distribution of reports across latitude, with each latitude zone containing approximately the same number of reports. It helps to correct, in other words, for any marked geographical skewness in the data base. This approach is adopted here, using 5 groups (20% percentiles), which conveniently distinguishes Tasmania as the fifth group (40°S +).

**Statistical analyses**

The ethnographic data, consisting of all the first-hand observations for mainland and Tasmanian Aborigines in the pre- and post-settlement periods, and coded for the four variables denoted as naked, clothed, shelter and morphology as outlined above, have been entered into an SPSS® data file. In this file, each observation comprises a "case", and the variables are scored digitally. Clothing and nakedness are coded separately as 0 = negative or absent, and 1 = affirmative or present, for the overall category and for each of the gender variables. This gives a total of six basic "naked" / "clothed" variables. Shelter is divided into three basic variables, "none", "windbreak", and "hut", while morphology is divided into "linear" and "stocky". This gives eleven basic dependent variables, viz. "naked", "clothed", "naked - males", "naked - females", "clothes - males", "clothes - females", "no shelter", "windbreak", "hut", "linear", and "stocky". From these, two major combined variables were created, an overall "naked - clothed" variable (0 = naked, 1 = clothes) and an overall morphology variable (0 = stocky, 1 = linear).

Thermal indices comprise the independent variables. These are latitude, season, 9am temperature, 9am wind speed, minimum July temperature, annual average daily minimum temperature, and two wind chill measures (9am monthly, and annual average using the annual average minimum temperature and average annual wind speed). Season comprised 4 groups, coded as 1 = summer, 2 = autumn, 3 = winter, 4 = spring. Percentile groups were generated for the other thermal indices as for latitude, resulting in 5 (20% percentile) groups on each variable. As with latitude, the use of percentile groups for the thermal indices helps to compensate for any skewness in the ranges of the thermal indices, which results from the geographical skewness in the distribution of ethnographic reports. Subsequent to the data collection, longitude was added, which had to be derived from the matched meteorological stations rather than from the ethnographic reports, but this should give an adequate approximation; longitude was likewise grouped into five (20%) percentile groups.

In the data base, each of the ethnographic cases is first assigned to one of four sections, corresponding to pre- and post-settlement eras for the mainland and Tasmania:

1.1 Tasmania: pre-1803
1.2 Tasmania: 1803+
1.3 Mainland: pre-1788
1.4 Mainland: 1788+

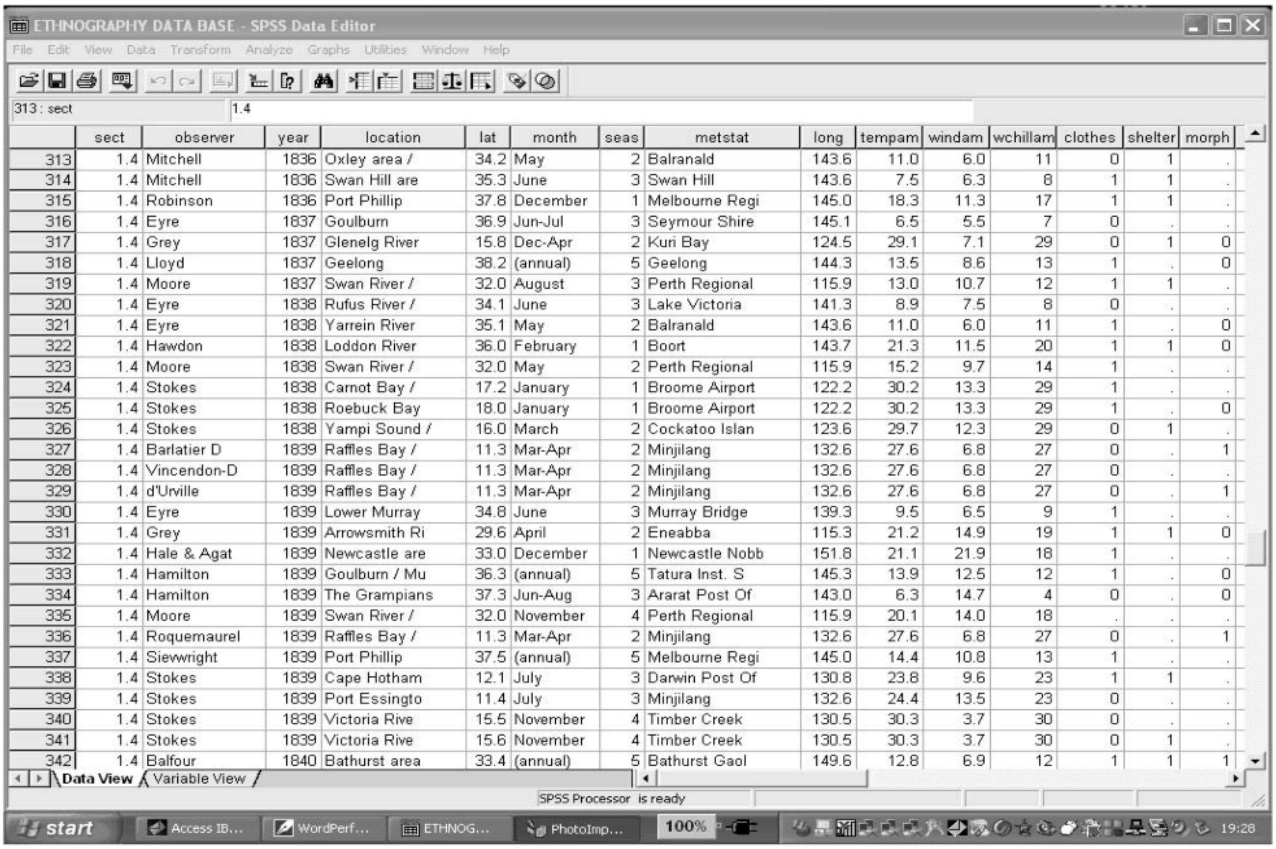
These four sections allow ready comparison of distributions on each dependent variable between Tasmania and the mainland, and the two combined, for the pre- and post-settlement periods. Within each section, the cases are ordered chronologically by year, and within years the ordering is alphabetical. To examine temporal distributions, the years are coded by decade, excepting the pre-settlement cases which are assigned either to "pre-1770" or thereafter to decade, and the few cases from the twentieth century, assigned to 1900+.

Figure 4 is an abbreviated sample from the ethnographic data base, showing some of the variables and their codings for a number of the ethnographic cases.

In testing the null hypotheses, viz. the distribution of Aboriginal clothing in relation to thermal indices, the Tasmanian clothing paradox, and the extent of Tasmanian morphological distinctiveness, chi-square ($\chi^2$) testing is the most appropriate widely-used statistic.

*Chi-square tests*

The chi-square test examines relationships between categorical, or discrete, variables (Tabachnick and Fidell 2001: 55, Moore 2003: 529-552). It compares observed frequencies in "cells" defined by the categories, e.g. clothing, and latitude zone, against expected frequencies if there were no relationship between the variables. It also assesses the significance of any relationship that is apparent in the results. The null hypothesis is that no significant relationship exists. If expected frequencies prove a poor fit to observed frequencies (resulting in a large $\chi^2$), the null hypothesis can be rejected. Chi-square tests are, therefore, a simple statistical approach for testing null hypotheses involving discrete or categorical variables.



ETHNOGRAPHY DATA BASE - SPSS Data Editor

313 : sect 1.4

| | sect | observer | year | location | lat | month | seas | metstat | long | tempam | windam | wchillam | clothes | shelter | morph |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 313 | 1.4 | Mitchell | 1836 | Oxley area / | 34.2 | May | 2 | Balranald | 143.6 | 11.0 | 6.0 | 11 | 0 | 1 | . |
| 314 | 1.4 | Mitchell | 1836 | Swan Hill are | 35.3 | June | 3 | Swan Hill | 143.6 | 7.5 | 6.3 | 8 | 1 | 1 | . |
| 315 | 1.4 | Robinson | 1836 | Port Phillip | 37.8 | December | 1 | Melbourne Regi | 145.0 | 18.3 | 11.3 | 17 | 1 | 1 | . |
| 316 | 1.4 | Eyre | 1837 | Goulburn | 36.9 | Jun-Jul | 3 | Seymour Shire | 145.1 | 6.5 | 5.5 | 7 | 0 | . | . |
| 317 | 1.4 | Grey | 1837 | Glenelg River | 15.8 | Dec-Apr | 2 | Kuri Bay | 124.5 | 29.1 | 7.1 | 29 | 0 | 1 | 0 |
| 318 | 1.4 | Lloyd | 1837 | Geelong | 38.2 | (annual) | 5 | Geelong | 144.3 | 13.5 | 8.6 | 13 | 1 | . | 0 |
| 319 | 1.4 | Moore | 1837 | Swan River / | 32.0 | August | 3 | Perth Regional | 115.9 | 13.0 | 10.7 | 12 | 1 | 1 | . |
| 320 | 1.4 | Eyre | 1838 | Rufus River / | 34.1 | June | 3 | Lake Victoria | 141.3 | 8.9 | 7.5 | 8 | 0 | . | . |
| 321 | 1.4 | Eyre | 1838 | Yarrein River | 35.1 | May | 2 | Balranald | 143.6 | 11.0 | 6.0 | 11 | 1 | . | 0 |
| 322 | 1.4 | Hawdon | 1838 | Loddon River | 36.0 | February | 1 | Boort | 143.7 | 21.3 | 11.5 | 20 | 1 | 1 | 0 |
| 323 | 1.4 | Moore | 1838 | Swan River / | 32.0 | May | 2 | Perth Regional | 115.9 | 15.2 | 9.7 | 14 | 1 | . | . |
| 324 | 1.4 | Stokes | 1838 | Carnot Bay / | 17.2 | January | 1 | Broome Airport | 122.2 | 30.2 | 13.3 | 29 | 1 | . | . |
| 325 | 1.4 | Stokes | 1838 | Roebuck Bay | 18.0 | January | 1 | Broome Airport | 122.2 | 30.2 | 13.3 | 29 | 1 | . | 0 |
| 326 | 1.4 | Stokes | 1838 | Yampi Sound / | 16.0 | March | 2 | Cockatoo Islan | 123.6 | 29.7 | 12.3 | 29 | 0 | 1 | . |
| 327 | 1.4 | Barlatier D | 1839 | Raffles Bay / | 11.3 | Mar-Apr | 2 | Minjilang | 132.6 | 27.6 | 6.8 | 27 | 0 | . | 1 |
| 328 | 1.4 | Vincendon-D | 1839 | Raffles Bay / | 11.3 | Mar-Apr | 2 | Minjilang | 132.6 | 27.6 | 6.8 | 27 | 0 | . | . |
| 329 | 1.4 | d'Urville | 1839 | Raffles Bay / | 11.3 | Mar-Apr | 2 | Minjilang | 132.6 | 27.6 | 6.8 | 27 | 0 | . | 1 |
| 330 | 1.4 | Eyre | 1839 | Lower Murray | 34.8 | June | 3 | Murray Bridge | 139.3 | 9.5 | 6.5 | 9 | 1 | . | . |
| 331 | 1.4 | Grey | 1839 | Arrowsmith Ri | 29.6 | April | 2 | Eneabba | 115.3 | 21.2 | 14.9 | 19 | 1 | 1 | 0 |
| 332 | 1.4 | Hale & Agat | 1839 | Newcastle are | 33.0 | December | 1 | Newcastle Nobb | 151.8 | 21.1 | 21.9 | 18 | 1 | . | . |
| 333 | 1.4 | Hamilton | 1839 | Goulburn / Mu | 36.3 | (annual) | 5 | Tatura Inst. S | 145.3 | 13.9 | 12.5 | 12 | 1 | . | 0 |
| 334 | 1.4 | Hamilton | 1839 | The Grampians | 37.3 | Jun-Aug | 3 | Ararat Post Of | 143.0 | 6.3 | 14.7 | 4 | 0 | . | 0 |
| 335 | 1.4 | Moore | 1839 | Swan River / | 32.0 | November | 4 | Perth Regional | 115.9 | 20.1 | 14.0 | 18 | . | . | . |
| 336 | 1.4 | Roquemaurel | 1839 | Raffles Bay / | 11.3 | Mar-Apr | 2 | Minjilang | 132.6 | 27.6 | 6.8 | 27 | 0 | . | 1 |
| 337 | 1.4 | Siewwright | 1839 | Port Phillip | 37.5 | (annual) | 5 | Melbourne Regi | 145.0 | 14.4 | 10.8 | 13 | 1 | . | . |
| 338 | 1.4 | Stokes | 1839 | Cape Hotham | 12.1 | July | 3 | Darwin Post Of | 130.8 | 23.8 | 9.6 | 23 | 1 | 1 | . |
| 339 | 1.4 | Stokes | 1839 | Port Essingto | 11.4 | July | 3 | Minjilang | 132.6 | 24.4 | 13.5 | 23 | 0 | . | . |
| 340 | 1.4 | Stokes | 1839 | Victoria Rive | 15.5 | November | 4 | Timber Creek | 130.5 | 30.3 | 3.7 | 30 | 0 | . | . |
| 341 | 1.4 | Stokes | 1839 | Victoria Rive | 15.6 | November | 4 | Timber Creek | 130.5 | 30.3 | 3.7 | 30 | 0 | 1 | . |
| 342 | 1.4 | Balfour | 1840 | Bathurst area | 33.4 | (annual) | 5 | Bathurst Gaol | 149.6 | 12.8 | 6.9 | 12 | 1 | 1 | 1 |

Figure 4 Ethnographic data base (sample)

# Chapter 6 Results and Discussion

## Results

Results from the analyses are presented in three sections:

1. Clothing,
2. Shelter, and
3. Morphology.

First, the data base is reviewed, and examined for trends in terms of the following:

1. Excluded cases (missing variables),
2. Latitudinal and longitudinal frequencies (geographical coverage), and
3. Temporal coverage and trends.

**Data Examination**

A total of 450 ethnographic reports were surveyed. A few yielded no suitable data, but are included due to their historical importance, for instance Jansz 1606, Tasman 1642, La Perouse 1788, and Hayes 1793. Commodore Hayes, for example, spent six weeks in southeast Tasmania – the longest European visit prior to colonial settlement – yet no first-hand records have been recovered. Most of the other cases which did not contribute to the clothing analyses were included as they yielded data on the other variables, particularly morphology. Some expeditions and explorers contributed a disproportionate number of reports, e.g. Cook's first and third Pacific voyages (22 and 6 reports respectively), Mitchell (29), the D'Entrecasteaux and Baudin expeditions (13 each), Robinson (22), Flinders (15), Stokes (14), and Giles (11). In some instances, the various observers describe the same events or the same Aboriginal people, so there is a degree of duplication. Nevertheless there is considerable variation in the descriptions, especially with respect to morphology, so multiple accounts are included. In other cases, such as the Baudin expedition and Robinson's account of the Flinders Island settlements, observations covering prolonged periods (e.g. a few weeks or months) at one location have sometimes been collapsed into single reports, as the descriptions are uniform and repetitious. There are 19 reports from the Sydney area by observers who arrived on the First Fleet. The total number of observers utilised in the data base is 202.

*Excluded cases*

The number of excluded cases varies in the different analyses depending on the variables examined, and appears in the statistical output as "missing cases". The results shown here do not include missing cases, as to do so would render the graphs more complex without contributing to their utility. The number of included cases is shown on the vertical axes as "number of ethnographic reports", so the number of missing cases is indicated by the difference between 450 and the total for all the bars in the graph. The greatest number of missing cases occur for the shelter and morphology variables, as descriptions of clothing or nakedness were the primary inclusion criteria for the study:

| | Valid | Missing | Total |
|---|---|---|---|
| Naked - clothed | 389 | 61 | 450 |
| | (86.4%) | (13.6%) | (100%) |
| Huts | 170 | 280 | 450 |
| | (37.8%) | (62.2%) | (100%) |
| Linear - stocky | 176 | 274 | 450 |
| | (39.1%) | (60.9%) | (100%) |

Statistically, missing cases can generally be ignored where they comprise < 5% of the total; where this is exceeded, as occurs here, it is more the pattern than the amount which is important (Tabachnick and Fidell 2001: 58-59). If their distributions are more-or-less random, missing cases may pose no serious problems; the problems are also of less concern with large data sets, as pertains here.

The distributions for shelter and morphology (Figures 5 and 6) show missing cases distributed quite evenly across latitude categories — especially with morphology, which is of more interest here. This random distribution compensates for the high frequencies of missing cases.

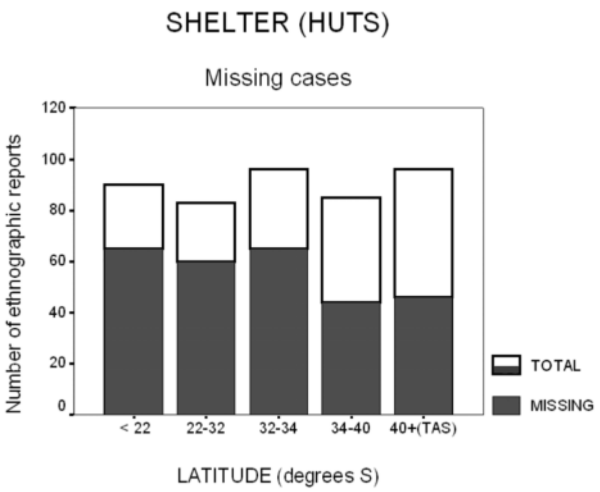



Figure 5 Missing cases - shelter

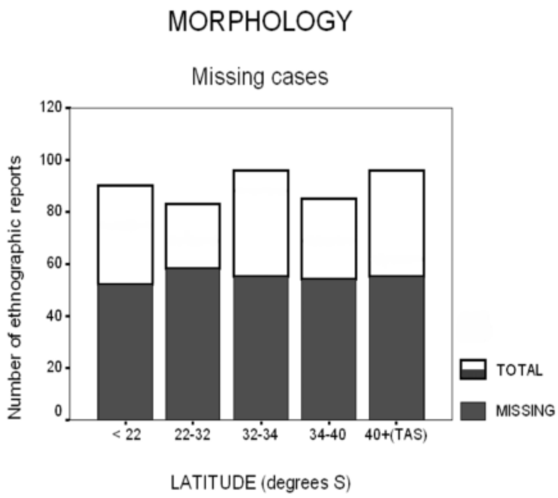



Figure 6 Missing cases - morphology

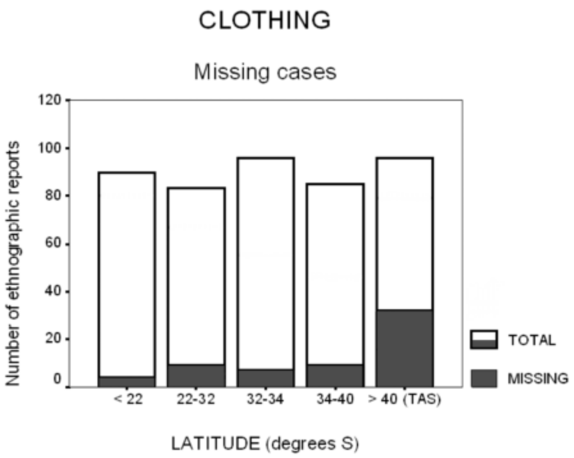



Figure 7 Missing cases - clothing

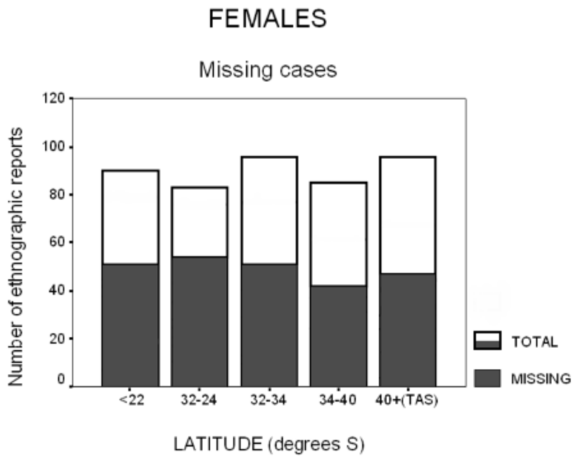



Figure 8 Missing cases - females

For clothing and nakedness (Figure 7), the situation is less straightforward. The distributions of missing cases for the mainland are low and reasonably uniform. For Tasmania, however, the number of cases is higher, rising to between 20% and 40% on some variables. This reflects the inclusion of numerous cases from the post-settlement period, mainly from Flinders Island, where the situation was complicated by the imposition of European-style clothing. Most of these cases are coded as "ambiguous", as the use of indigenous garments is of paramount interest here, and they are then excluded from the analyses.

The other problem with missing cases occurs with gender, where the proportion of missing cases for females reaches levels between 40% and 50% (Figure 8). This arises because females were generally less accessible to observation, often being kept at a distance from the Europeans by the males. In addition, many accounts do not specify gender, referring simply to "natives", for example. In most instances, it is reasonable to assume that males were observed, as the presence of any females was generally noted at the time. For these reasons, the unspecified observations are coded as "male", adding to the disproportionately high frequency of missing cases for females.

*Geographical coverage*

The data are skewed heavily towards the southeastern areas, reflecting both historical and experimental (i.e. study-based) factors. Historically, while the earliest visits by Europeans were to the northern and western coasts, the majority of subsequent visits were to the eastern and southeastern coasts. None of the pre-colonial visits involved observations beyond the coastal fringes. In the early decades of the colonial or post-settlement era, the European presence was predominantly in the southeast. With respect to "experimental" bias in sampling for the study, this has compounded the problem. Given the comparative paucity of data on the Tasmanian Aborigines, an emphasis is placed on extracting maximum information from the available records for Tasmania, which adds to the plethora of cases from the southeast.

The frequency histograms show latitude based on number of ethnographic reports (Figure 9), and longitude based on number of matched meteorological stations (Figure 10). If not for the inclusion of reports from the central and western desert areas dating to the second half of the nineteenth century, the geographical distribution would be more skewed.

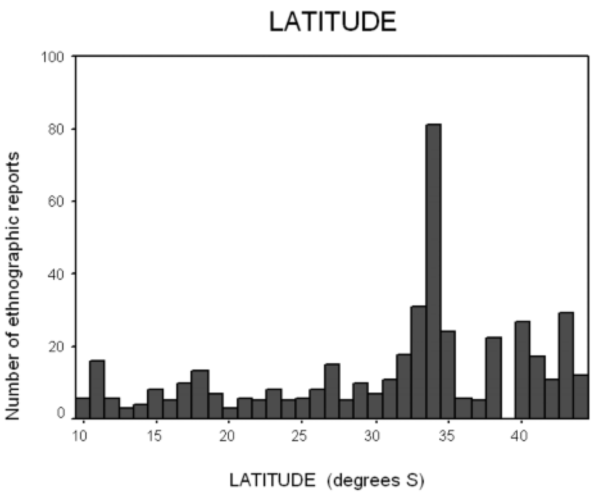



Figure 9 Ethnographic reports by latitude

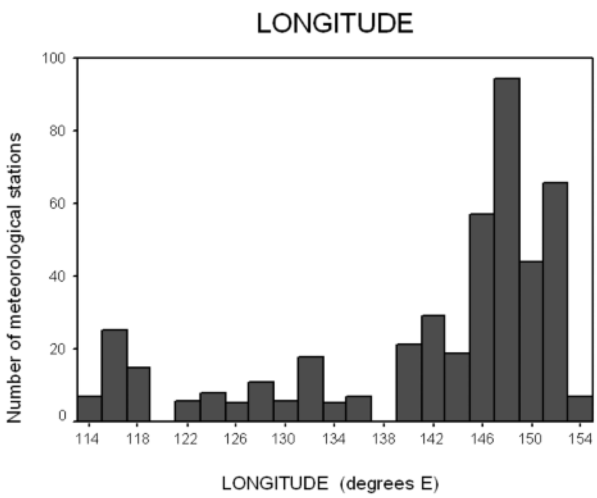



Figure 10 Ethnographic reports by longitude

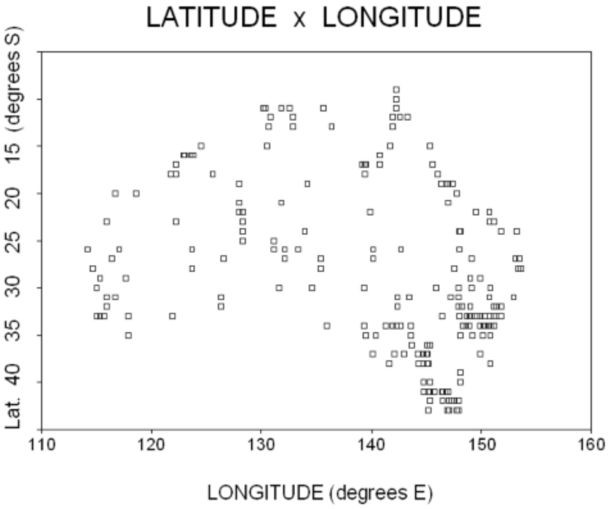


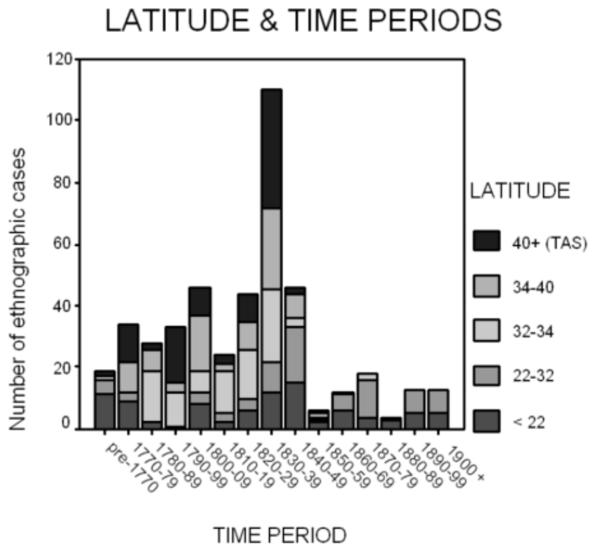

Figure 11 Latitude × longitude

The data in these two histograms are combined in the scatterplot (Figure 11). It demonstrates adequate geographical coverage, and bears an approximate resemblance to the shape of the study area.

From a statistical point of view, the skewed distribution of cases would present major problems for parametric techniques such as correlations, t-tests and analysis of variance, which assume normal or near-normal distributions of continuous variables. In the present study, the independent variables of interest (e.g. latitude, temperature, wind chill) are continuous, and the skewed geographical bias results in non-normal distributions. Procedures are available to compensate, including transformation into normally-distributed variables, but the use of such procedures remains controversial, and interpretation of results becomes more complex (Pallant 2001: 78-81, Tabachnick and Fidell 2001: 80-86). Moreover, the problem of a skewed distribution is reduced with a large sample size, whereas the benefits of transformation may be marginal. The non-parametric techniques appropriate for discrete or categorical variables (such as naked vs. clothed, or linear vs. stocky) do not have such stringent requirements. Given that the dependent variables in this study are categorical, an alternative to transformation is to collapse the continuous variables into categories or groups. The continuous variables examined in this study, such as latitude and the various thermal indices, remain meaningful and readily interpretable when collapsed into groups, so this strategy has been adopted.

*Temporal trends*

The geographical skewness of the data are compounded by temporal aspects. These arise, as mentioned above, from the historical pattern of early exploration and settlement. Ideally, the post-settlement ethnographic data should be restricted to the first few decades of the colonial era, as such data will become less reliable with increasing potential exposure to such influences. However, not only was the collection of data itself dependent upon such exposure, but



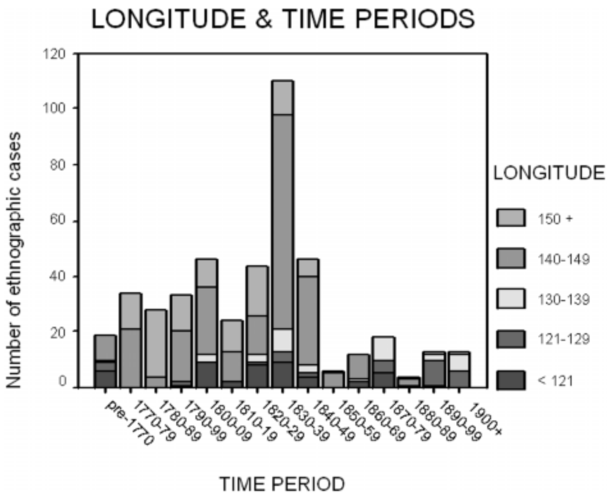
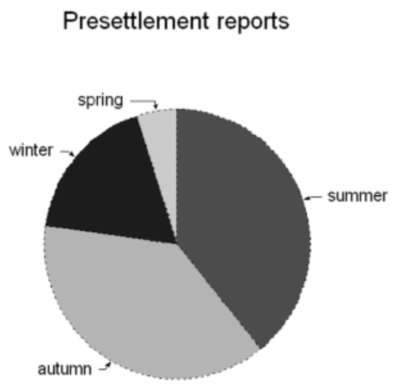
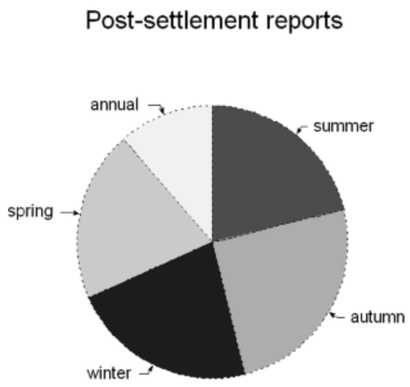




Figure 12 (upper) Latitude and time periods
Figure 13 (lower) Longitude and time periods

the early settlement-era records derive predominantly from the southeastern areas. Restricting the analyses to, say, the first half of the nineteenth century would lead to further over-representation of the southeast, as much of the continent's interior remained unexplored by white settlers until the latter part of that century. These patterns are evident in Figures 12 and 13, which show the distribution in the data base of latitudinal and longitudinal categories respectively against time periods.

Another temporal aspect is the seasonal distribution of the ethnographic reports. One concern is that European visitors in the pre-settlement era would tend to schedule their voyages across the southern oceans when maritime conditions were more favourable, namely during the warmer months, and would tend to avoid the stormier winter months where possible. To examine this aspect, the ethnographic reports are coded for season. In some cases, the season is not ascertained, in which instance the report is coded as "annual" (and the corresponding meteorological data are annual rather than monthly averages). The "annual" category also includes reports covering whole years.



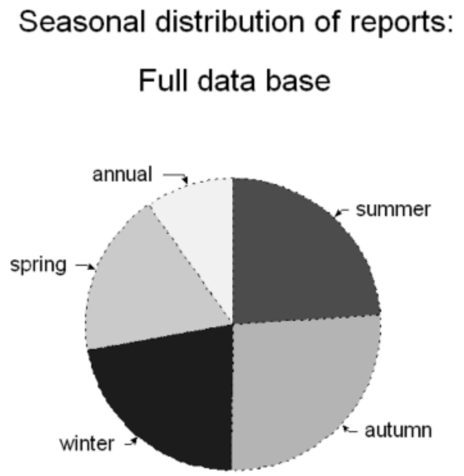




Figure 14 (above left) Seasonal distributions: pre-settlement reports
Figure 15 (above centre) Seasonal distributions: post-settlement reports
Figure 16 (above right) Seasonal distributions: full data base

The seasonal distribution of the pre-settlement data is shown in Figure 14.

In contrast to the pre-settlement reports, those from the settlement era (Figure 15) are distributed more evenly, with comparatively more cases in winter and especially in spring. One reason for the different seasonal distribution may simply be that European settlement entailed a year-round presence. Also, exploration of the continent, especially away from the coastal zones, was more arduous during summer, and even dangerous given the difficulties in securing access to sources of fresh water, which were more likely to be dry during summer. Ideally, the seasonal distribution of reports for the entire data base should be approximately uniform across seasons, and this appears to be the case (Figure 16). Of the 450 reports, 40 are assigned to the "annual" category, representing 8.9% of the total.

**Analyses**

*Clothing*

For most of the clothing analyses, a single "naked – clothed" variable is used to simplify presentation of results, combining the "naked" and "clothed" codings. Where the two are coded as present in a single report, priority is given to the presence of clothing. Where gender differences occur, as for instance where males may be reported as "naked" and females as wearing garments, priority is given to the "naked" status of the males. This takes account of the likelihood that females were generally delegated the responsibility of carrying items such as garments and rugs, which may distort the results. Gender differences in clothing reports are shown separately, using the original variables for males and females.

Temporal trends in reports of Aboriginal clothing are considered first. Trends on the "naked - clothed" variable over time are shown, together with results comparing the pre-settlement and settlement-era periods for the mainland and Tasmania.

For the overall time picture (Figure 17), there is an increase in clothing reports over the first few decades after European settlement, reversing from the 1840's onwards. As discussed below, this may reflect changing patterns of European settlement and exploration. In the pre-settlement *v.s.* settlement-era graph (Figure 18), reports of clothing are more frequent in the settlement-era periods for both the mainland and Tasmania. In the pre-settlement periods, clothing reports are more frequent in Tasmania. This is not so unexpected in itself, the clothing paradox notwithstanding, as all the mainland pre-settlement reports are located along the northern and western coasts.

To examine the Tasmanian clothing paradox, reports of nakedness or clothing are compared between Tasmania and mainland, with the latter being divided into regions to determine whether or not Tasmania follows any overall trends.

Division can be effected by calculating percentiles based on latitude (Table 1). With five latitudinal groups, each comprising 20% of the total ethnographic sample, the fifth percentile corresponds to ≥40°S. This distinguishes Tasmania from the four groups covering the mainland.

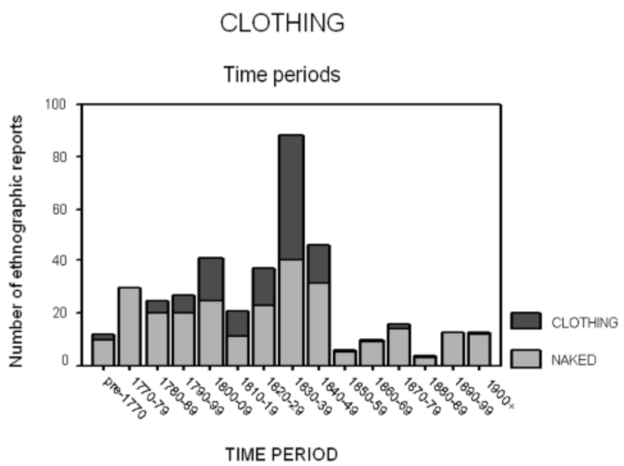



Figure 17 Naked - clothed: time periods

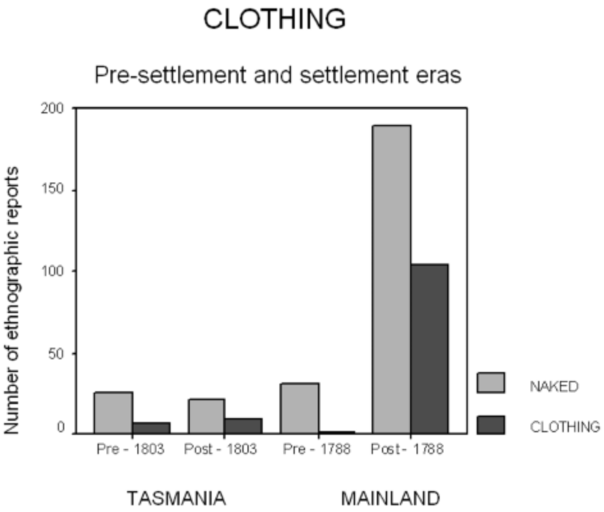



Figure 18 Naked - clothed: pre- and post-settlement eras

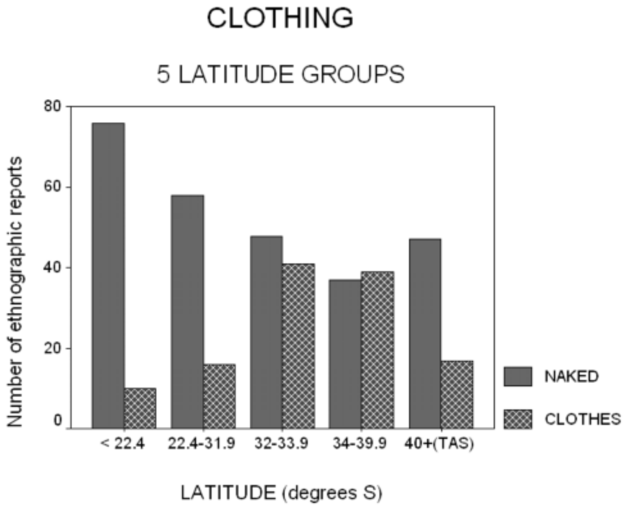



Figure 19 Clothing: five latitude groups

**Statistics**

**LATITUDE**

| | | |
|---|---|---|
| N | Valid | 450 |
| | Missing | 0 |
| Percentiles | 20 | 21.900 |
| | 40 | 32.000 |
| | 60 | 34.000 |
| | 80 | 40.000 |

Table 1

Five (20%) latitude percentiles

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 42.303[a] | 4 | .000 |
| Likelihood Ratio | 44.127 | 4 | .000 |
| Linear-by-Linear Association | 15.644 | 1 | .000 |
| N of Valid Cases | 389 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.24.

Table 2 Clothing and latitude: chi-square results

Thermal trends in Aboriginal clothing use can also be examined by similarly calculating percentiles for the various thermal indices, such as mean and minimum temperature, and wind chill, as shown below.

The clothing paradox can be examined by comparing the five latitudinal groups on the “naked - clothed” variable (Figure 19). For the four mainland groups, there is a clear trend of decreasing “naked” reports with increasing latitude. For the reports of clothing, there is an inverse trend of increasing reports with increasing latitude, although it tends to plateau in the most southerly region. Beyond 40°S, these trends reverse. Chi-square results are shown in Table 2, while Table 3 compares the actual and expected counts (shown in the first two rows) in each of the five latitude groups. An alternative way of presenting these results is by showing the frequencies of the five latitudinal groups on the “naked - clothed” variable (Figure 20). Again, the mainland trend is evident, and equally evident is the reversal of this trend in Tasmania.

To examine the thermal indices, 20% percentiles are used to generate five groups on each of the variables. These analyses are most useful for examining the extent to which Aboriginal use of clothing corresponds with thermal zones.

For these variables, there is no direct correspondence between the percentile groups and geographical regions.

While Tasmania cannot be identified as readily as for the latitudinal groups, the clothing paradox may be expected to result in a divergent trend for the colder thermal groups.

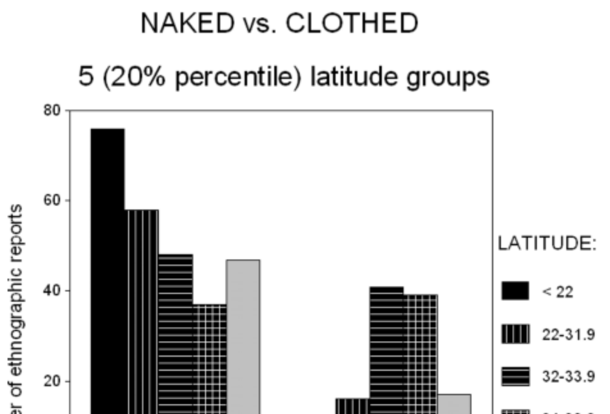



Figure 20 Latitude groups: naked *vs.* clothed

**5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) * NAKED CLOTHED Crosstabulation**

| | | | NAKED 0 | CLOTHED 1 | Total |
|---|---|---|---|---|---|
| 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 1 | Count | 76 | 10 | 86 |
| | | Expected Count | 58.8 | 27.2 | 86.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 88.4% | 11.6% | 100.0% |
| | | % within NAKED CLOTHED | 28.6% | 8.1% | 22.1% |
| | | % of Total | 19.5% | 2.6% | 22.1% |
| | 2 | Count | 58 | 16 | 74 |
| | | Expected Count | 50.6 | 23.4 | 74.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 78.4% | 21.6% | 100.0% |
| | | % within NAKED CLOTHED | 21.8% | 13.0% | 19.0% |
| | | % of Total | 14.9% | 4.1% | 19.0% |
| | 3 | Count | 48 | 41 | 89 |
| | | Expected Count | 60.9 | 28.1 | 89.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 53.9% | 46.1% | 100.0% |
| | | % within NAKED CLOTHED | 18.0% | 33.3% | 22.9% |
| | | % of Total | 12.3% | 10.5% | 22.9% |
| | 4 | Count | 37 | 39 | 76 |
| | | Expected Count | 52.0 | 24.0 | 76.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 48.7% | 51.3% | 100.0% |
| | | % within NAKED CLOTHED | 13.9% | 31.7% | 19.5% |
| | | % of Total | 9.5% | 10.0% | 19.5% |
| | 5 | Count | 47 | 17 | 64 |
| | | Expected Count | 43.8 | 20.2 | 64.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 73.4% | 26.6% | 100.0% |
| | | % within NAKED CLOTHED | 17.7% | 13.8% | 16.5% |
| | | % of Total | 12.1% | 4.4% | 16.5% |
| Total | | Count | 266 | 123 | 389 |
| | | Expected Count | 266.0 | 123.0 | 389.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 68.4% | 31.6% | 100.0% |
| | | % within NAKED CLOTHED | 100.0% | 100.0% | 100.0% |
| | | % of Total | 68.4% | 31.6% | 100.0% |

Table 3 Clothing and latitude: actual and expected counts

To examine the thermal indices, 20% percentiles are used to generate five groups on each of the variables. These analyses are most useful for examining the extent to which Aboriginal use of clothing corresponds with thermal zones.

**Statistics**

**9am MEAN TEMPERATURE (C)**

| | | |
|---|---|---|
| N | Valid | 450 |
| | Missing | 0 |
| Percentiles | 20 | 12.700 |
| | 40 | 15.100 |
| | 60 | 18.560 |
| | 80 | 23.700 |

Table 4 9am temperature: five (20%) percentiles

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 28.575[a] | 4 | .000 |
| Likelihood Ratio | 28.718 | 4 | .000 |
| Linear-by-Linear Association | 25.021 | 1 | .000 |
| N of Valid Cases | 389 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 23.08.

Table 5 9am temperature and clothing: chi-square results

The first thermal index is mean 9am air temperature (Figure 21). This is a monthly average in most cases, but the annual average is used for those reports (8.9%) where more precise dating was not possible, or where the report covered one or more years of observation. Statistics for calculating percentiles for the five groups, and results of chi-square tests, are shown in Tables 4 and 5.

Results for wind chill, based on 9am monthly temperature and 9am monthly average wind speed (except where annual averages were used), are shown in Figure 22 and in Tables 6 and 7. While the wind chill results do not identify Tasmania directly, the relationship between the wind chill groups and latitude groups can be represented as shown in

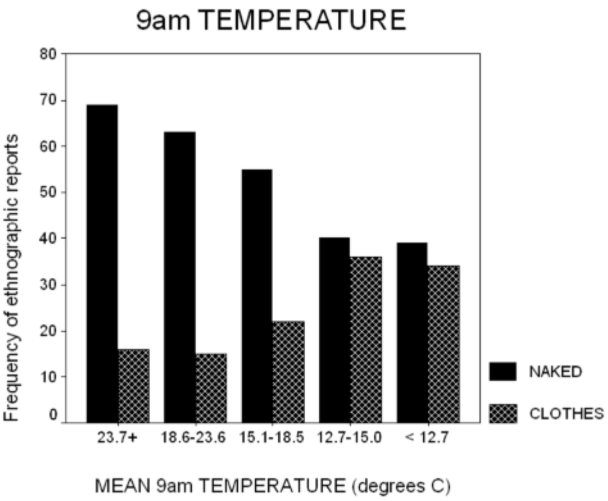



Figure 21 9am temperature: naked *vs.*clothed

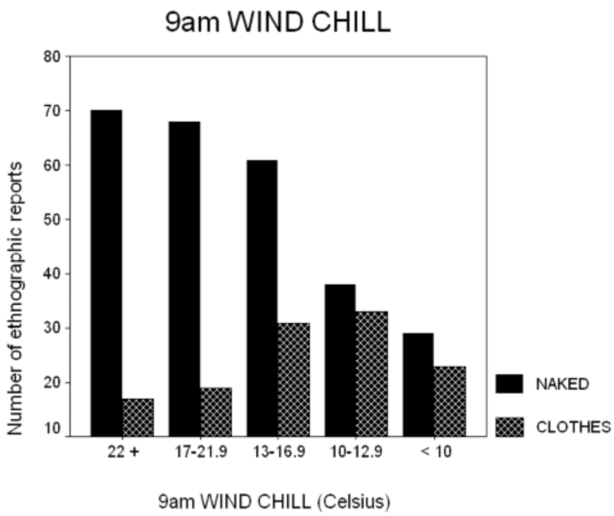



Figure 22 9am wind chill groups: naked *vs.* clothed

**Statistics**

**9am WIND CHILL (Steadman)**

| | | |
|---|---|---|
| N | Valid | 450 |
| | Missing | 0 |
| Percentiles | 20 | 10.00 |
| | 40 | 13.00 |
| | 60 | 17.00 |
| | 80 | 22.00 |

Table 6

9am wind chill: five (20%) percentile groups

Figure 23. The colder wind chill categories predominate in Tasmania, where the two warmest categories are virtually absent. Also, the colder wind chill temperatures are seen in the middle latitude zone, more so than in the most southerly region of the continent. This middle zone includes the southwestern areas of the continent.

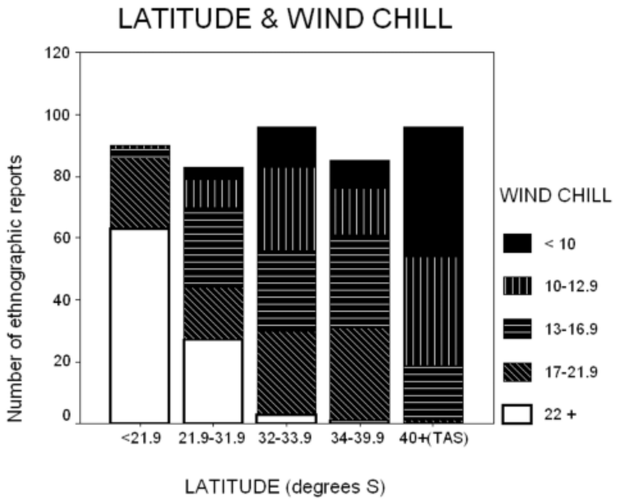



Figure 23 Latitude and wind chill groups

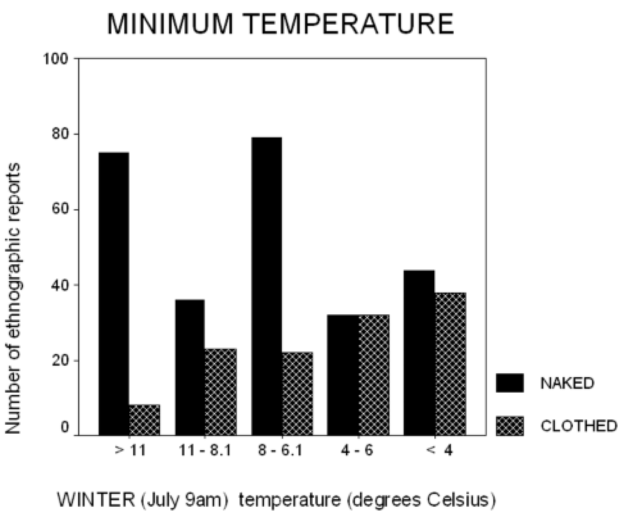



Figure 24 Minimum winter temperature groups: naked *vs.* clothed

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 20.979[a] | 4 | .000 |
| Likelihood Ratio | 21.128 | 4 | .000 |
| Linear-by-Linear Association | 18.781 | 1 | .000 |
| N of Valid Cases | 389 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 16.44.

Table 7 9am wind chill and clothing: chi-square results

Results for winter (July ) average minimum temperature are shown in Figure 24. Also shown are results using a combination of mean annual minimum temperature and mean annual wind speed (Figure 25). This combination, while not strictly a "wind chill" estimate, gives an indication of overall minimum temperatures and windiness. Chi-square results for this last thermal variable in relation to the "naked - clothes" variable are shown in Table 8.

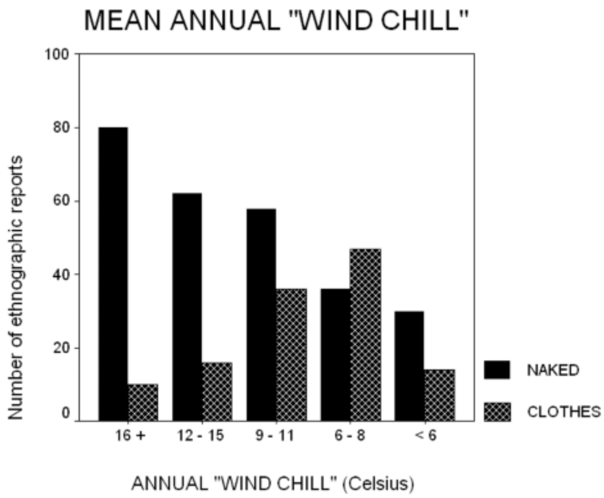



Figure 25 Annual wind chill groups: naked *vs.* clothed

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 47.903[a] | 4 | .000 |
| Likelihood Ratio | 49.740 | 4 | .000 |
| Linear-by-Linear Association | 30.117 | 1 | .000 |
| N of Valid Cases | 389 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.91.

Table 8 Annual "wind chill" and clothing: chi-square results

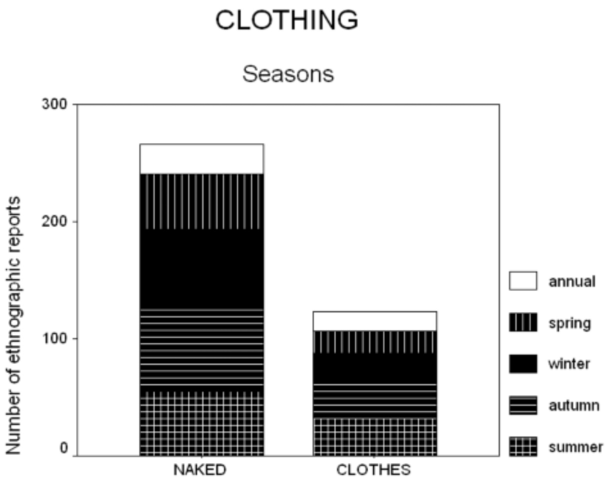



Figure 26 Seasonal distributions of "naked" and "clothed" reports

Results for seasonal distribution of ethnographic reports (Figure 26) show no differences in the relative frequencies of the seasons for either "naked" or "clothed" reports. Specifically, reports of clothing appear no more frequent in the colder months. Chi-square tests on expected versus observed frequencies between groups are not statistically significant.

Gender differences in clothing reports are examined using the original "naked" and "clothes" codings by gender. The distributions on the five latitude groups are presented, with the fifth group representing Tasmania. For males, the distributions of the variables "naked - males" and "clothes - males" are shown in Figures 27 and 28. Chi-square tests show significant differences between expected and observed frequencies in the latitude groups in both analyses. Results for "males - naked" and "males - clothes" are shown in Tables 9 and 10 respectively.

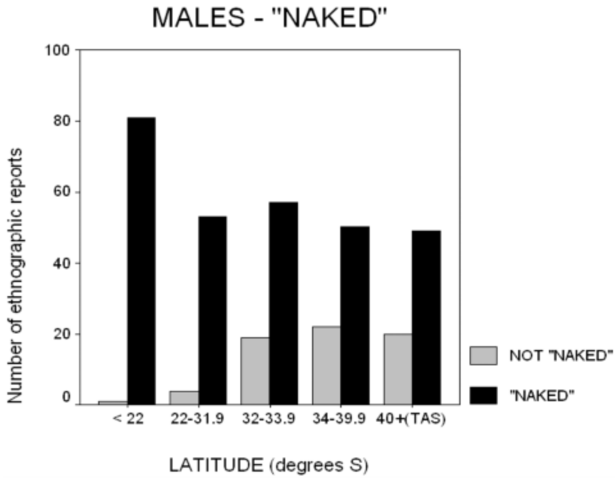



Figure 27 Males - "naked" and latitude groups

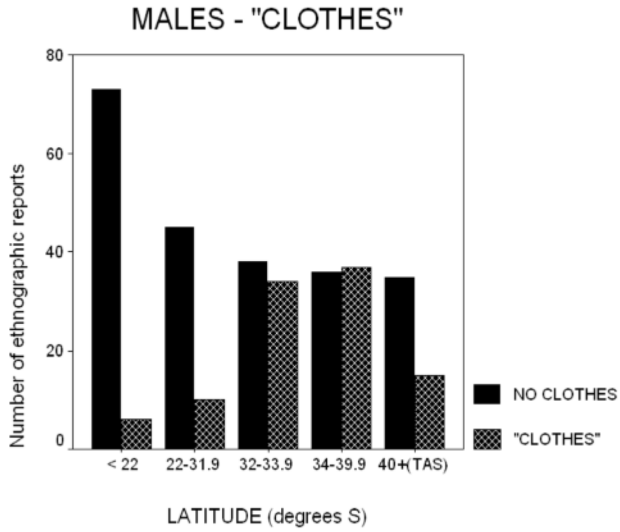



Figure 28 Males - "clothes" and latitude groups

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 35.268[a] | 4 | .000 |
| Likelihood Ratio | 44.432 | 4 | .000 |
| Linear-by-Linear Association | 30.358 | 1 | .000 |
| N of Valid Cases | 356 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.57.

Table 9 Males - "naked" and latitude: chi-square results

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 46.560[a] | 4 | .000 |
| Likelihood Ratio | 50.901 | 4 | .000 |
| Linear-by-Linear Association | 24.027 | 1 | .000 |
| N of Valid Cases | 329 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 15.50.

Table 10 Males - "clothes" and latitude: chi-square results

The latitudinal distributions for females are shown in Figures 29 and 30. Pearson chi-square tests again show highly significant differences between expected and observed outcomes for the latitude groups on both analyses. Results for the "females- naked" and "females - clothes" variables are shown in Tables 11 and 12 respectively.

The emphasis on reports of clothing in this study, and the relative frequencies of reports of "nakedness" and "clothing", should not be construed as suggesting that the use of clothing was at all commonplace in Aboriginal Australia. On the contrary, clothing of any kind was a comparative rarity in most areas, and was usually totally absent. The re-

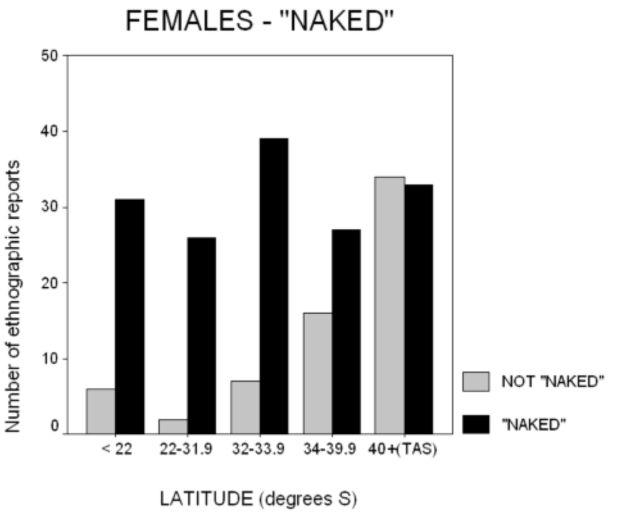



Figure 29 Females - "naked" and latitude groups

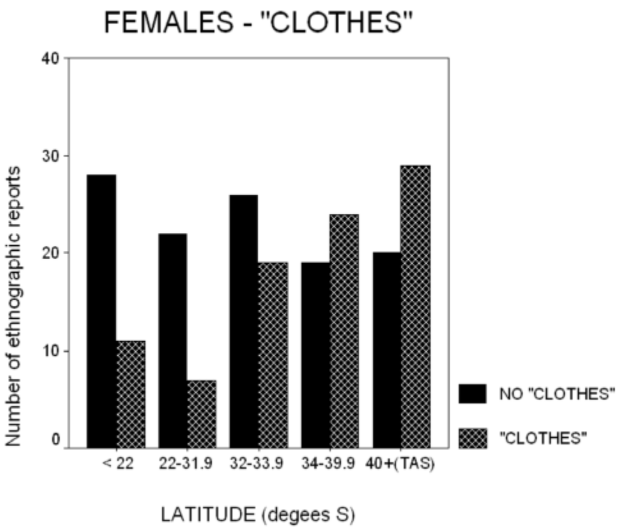



Figure 30 Females - "clothes" and latitude groups

ports of "nakedness" in the data base comprise only those instances where this situation was documented quite unambiguously. The ethnographic survey encountered many descriptions of Aborigines in which it could reasonably be inferred that no clothing existed, but where this was not stated explicitly. Such instances are not included in the data base. One exam ple is Charles Sturt, who met with many Aboriginal groups during his expedition into central Australia in the 1840's. However, none of the episodes related in the published journal refer specifically to clothing or its absence. For instance he notes on one occasion, in the "Stony Desert" area in the northeast of South Australia, that the "custom of lacerating their bodies does not seem to prevail among them, neither does that of circumcision" (Sturt 1984: 93). His summary of the expedition makes the general observation that there "is no people in the world so unprovided against inclemency or extremes of weather... They have literally nothing to cover them, to protect them from the summer heat or the winter's cold..." (ibid: 258). In many of the journal accounts, the usual lack of any clothes among Aborigines was taken as understood, especially by the middle of the nineteenth century. The less common situation, where some garments might be observed, was more likely to warrant a specific remark. For this reason, particularly with the post-settlement periods, the data base may better approximate the ethnographic situation for clothing than for nakedness, the reports of which will likely represent an under-estimate.

*Shelter*

Given the high proportion of missing cases on these variables, the results for shelter derive from smaller ethnographic samples than is the case for the clothing data. As shown earlier, the distribution of missing variables is quite uniform across the latitude groups, but the consequent small sample sizes are insufficient for statistical testing. The distributions for windbreaks and huts are shown in Figures 31 and 32 respectively.

*Morphology*

For morphology, a combined variable coded 0 = STOCKY and 1 = LINEAR was created from the original codings of ethnographic descriptions. The distribution of this combined morphology variable across the five latitude categories is shown in Figure 33. Results of chi-square tests and the expected versus observed frequencies in the five latitude groups are shown in Tables 13 and 14. The combined morphology variable was also examined in relation to wind

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 30.203[a] | 4 | .000 |
| Likelihood Ratio | 31.687 | 4 | .000 |
| Linear-by-Linear Association | 23.877 | 1 | .000 |
| N of Valid Cases | 221 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.24.

Table 11 Females - "naked" and latitude groups: chi-square results

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 15.677[a] | 4 | .003 |
| Likelihood Ratio | 16.095 | 4 | .003 |
| Linear-by-Linear Association | 14.000 | 1 | .000 |
| N of Valid Cases | 205 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.73.

Table 12 Females - "clothes" and latitude groups: chi-square results

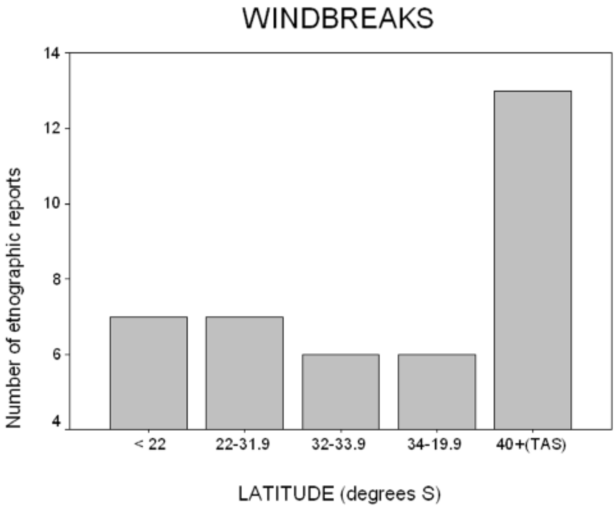



Figure 31 Shelter (windbreaks) and latitude groups

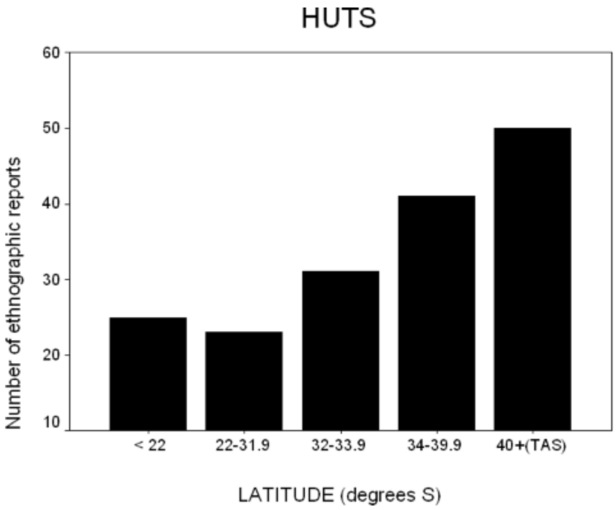



Figure 32 Shelter (huts) and latitude groups

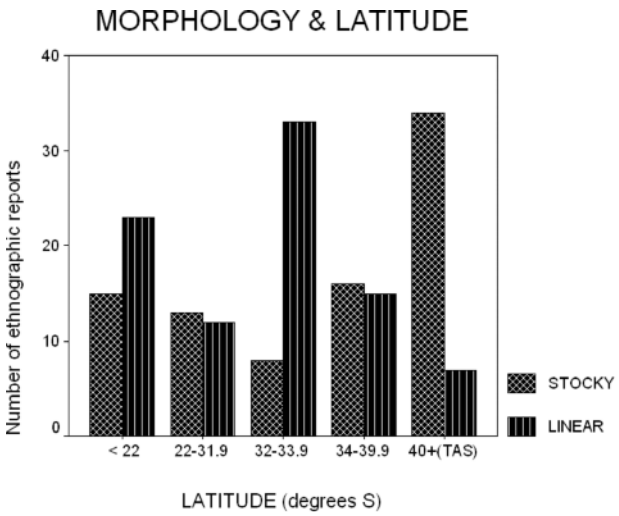



Figure 33 Morphology and latitude groups

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 34.708[a] | 4 | .000 |
| Likelihood Ratio | 37.404 | 4 | .000 |
| Linear-by-Linear Association | 13.235 | 1 | .000 |
| N of Valid Cases | 176 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.22.

**5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) * MORPHOLOGY - combined 1= linear 0= stocky Crosstabulation**

| | | | MORPHOLOGY - combined 1= linear 0= stocky | | |
|---|---|---|---|---|---|
| | | | 0 | 1 | Total |
| 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 1 | Count | 15 | 23 | 38 |
| | | Expected Count | 18.6 | 19.4 | 38.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 39.5% | 60.5% | 100.0% |
| | | % within MORPHOLOGY - combined 1= linear 0= stocky | 17.4% | 25.6% | 21.6% |
| | | % of Total | 8.5% | 13.1% | 21.6% |
| | 2 | Count | 13 | 12 | 25 |
| | | Expected Count | 12.2 | 12.8 | 25.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 52.0% | 48.0% | 100.0% |
| | | % within MORPHOLOGY - combined 1= linear 0= stocky | 15.1% | 13.3% | 14.2% |
| | | % of Total | 7.4% | 6.8% | 14.2% |
| | 3 | Count | 8 | 33 | 41 |
| | | Expected Count | 20.0 | 21.0 | 41.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 19.5% | 80.5% | 100.0% |
| | | % within MORPHOLOGY - combined 1= linear 0= stocky | 9.3% | 36.7% | 23.3% |
| | | % of Total | 4.5% | 18.8% | 23.3% |
| | 4 | Count | 16 | 15 | 31 |
| | | Expected Count | 15.1 | 15.9 | 31.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 51.6% | 48.4% | 100.0% |
| | | % within MORPHOLOGY - combined 1= linear 0= stocky | 18.6% | 16.7% | 17.6% |
| | | % of Total | 9.1% | 8.5% | 17.6% |
| | 5 | Count | 34 | 7 | 41 |
| | | Expected Count | 20.0 | 21.0 | 41.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 82.9% | 17.1% | 100.0% |
| | | % within MORPHOLOGY - combined 1= linear 0= stocky | 39.5% | 7.8% | 23.3% |
| | | % of Total | 19.3% | 4.0% | 23.3% |
| Total | | Count | 86 | 90 | 176 |
| | | Expected Count | 86.0 | 90.0 | 176.0 |
| | | % within 5 LAT GROUPS: 1=<22 2=22-32 3=32-34 4=34-40 5=>40(TAS) | 48.9% | 51.1% | 100.0% |
| | | % within MORPHOLOGY - combined 1= linear 0= stocky | 100.0% | 100.0% | 100.0% |
| | | % of Total | 48.9% | 51.1% | 100.0% |

Table 13 (above) Morphology and latitude: chi-square results

Table 14 (above right) Morphology and latitude: actual and expected counts

chill, using the same five wind chill groups as before. The distributions are shown in Figure 34, together with the results of chi-square tests in Table 15.

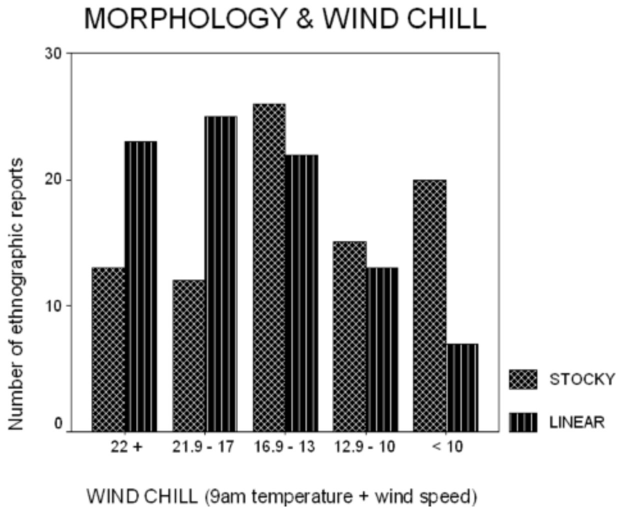



Figure 34 Morphology and wind chill groups

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 13.997[a] | 4 | .007 |
| Likelihood Ratio | 14.394 | 4 | .006 |
| Linear-by-Linear Association | 11.595 | 1 | .001 |
| N of Valid Cases | 176 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.19.

Table 15 Morphology and wind chill: chi-square results

## Discussion

The main clothing analysis compares ethnographic reports of clothing and nakedness across latitudinal zones. It shows a consistent trend across the mainland, which is reversed in Tasmania. The trend is one of decreasing nakedness, and increasing presence of clothes, with increasing latitude on the Australian mainland. The Tasmanian data fail to follow this trend. Given its higher latitude, Tasmania would be expected to have more frequent reports of clothing, and fewer reports of nakedness. Instead, clothing is less commonly reported, and nakedness more commonly reported, than for the southern zones of the mainland. Insofar as increasing latitude corresponds with lower average temperatures, the results suggest an essentially thermal pattern of clothing use in Aboriginal Australia. The reversal of this trend beyond the latitude of 40°S supports the existence of the Tasmanian clothing paradox.

The likelihood that this pattern reflects predominantly thermal factors is increased by the finding that similar trends emerge when clothing is examined in relation to thermal indices. Mean monthly 9am air temperatures matched to the ethnographic observations reveal the same trends, as do the data for 9am wind chill. When mean winter (July) minimum temperatures are examined, the same pattern is evident, although this applies more to reports of clothing than for nakedness. The latter thermal index, it may be noted, is not matched to the month of the observations. When mean annual minimum temperatures and mean annual wind speed are combined, this annualised "wind chill" variable shows a strong thermal trend with respect to clothing and nakedness, but this reverses for the coldest "wind chill" category. Seasonal variation, however, appears to have no relationship to frequency of reports for either nakedness or the presence of clothes, which is unexpected if thermal factors are paramount.

With respect to gender differences in the patterns of nakedness and use of clothing, the data for males is concordant with the overall trends. Reports of males with clothing increase with increasing latitude on the mainland, though the rate of increase slows for the most southerly zone, followed by a distinct reversal for Tasmania. The results for females show an overall trend of increasing clothes with increasing latitude, and no evidence of a reversal in Tasmania. Reports of nakedness for females show no major trends across latitude zones, being comparatively evenly distributed. The results for females suggest not only a lack of any Tasmania paradox, but an increase in reports of clothing in the lowest latitude zone, i.e. northern Australia.

The results for shelter may appear suggestive of latitudinal trends, but these are unreliable for a number of reasons. First, sample sizes are small and, in the case of windbreaks, insufficient for statistical analyses. Reports of huts show an increasing trend with latitude which extends to Tasmania, but chi-square tests of expected versus observed frequencies in the five latitude groups are not statistically significant. Parametric (Pearson correlation) tests using the frequency of huts in both five and ten latitude groups likewise fail to reach statistical significance.

The second reason for considering the shelter results unreliable is that the vast majority of the ethnographic reports only include shelter where the latter coincided with either reports of clothing or, in some cases, morphological descriptions that could be utilised in the analyses. Numerous accounts of Aboriginal shelters were encountered during the survey of the published literature, but only a very small proportion were included in the data base. The many accounts of shelter that were unaccompanied by descriptions of nakedness or clothes, or of morphological appearance, would need to be included to assemble a reasonably representative ethnographic base on Aboriginal shelter. This would constitute a major project in itself, as accounts of shelter in the literature are far more common than those of clothing or nakedness. It would be of interest, for instance in highlighting the need for shelter from rain (and sometimes from direct sunlight in the hottest regions), as well as protection from wind. There may be a suggestion in the early ethnographic accounts that less use was made of

artificial shelter in Tasmania than was generally the case on the mainland; many of the early visitors certainly made disparaging remarks to this effect. A comprehensive study of this question would provide a useful supplement to the Tasmanian clothing paradox. Indeed, if thermal factors are implicated in the clothing paradox and use of shelter was largely a thermal behaviour, a Tasmanian shelter paradox may not be unexpected.

The results for morphology are more reliable than for shelter, in that a higher proportion of descriptions encountered during the survey were included in the data base. Again, however, the results need to be approached with caution, and the morphology data base is not as extensive as that for clothing and nakedness (where every available description was included). Sample size for morphology is modest but adequate for statistical analyses, both with respect to its size (176 cases) and its distribution across the five latitude zones (viz. 38, 25, 41, 31 and 41 cases in the lowest to highest zones respectively, an average of 35.2 per category).

Ethnographic descriptions of the morphological appearance of Aborigines were coded where possible as indicating either a "linear" or "stocky"body build. Insofar as the descriptions can be so classified, the results show distinct trends when distributions are presented across the latitude categories. Reports coded as "stocky" reach a maximum in Tasmania, where those coded as "linear" also reach a minimum. On the mainland, however, the latitudinal trends are more complex. Reports coded as "stocky" are generally low, representing, on average, barely one third of the number for Tasmania, although the lowest frequency is found in the 32-33.9°S zone, rather than in the lowest latitude zones. Whether this represents a real trend, or is an artefact of modest sample sizes in the latitude groups, is difficult to determine. A comparable trend is evident for the "linear" coding, which peaks in the same 32-33.9°S category.

These mainland morphology results may reflect the fact that, from an environmental (particularly a thermal) perspective, latitude categories do not fully depict the major environmental trends. There may be significant east-west (i.e. longitudinal) and other trends that interact with the latitudinal trends. The southern zones, for instance, include those at higher altitudes in the southeast. Also, a disproportionate number of reports in the 32-33.9°S category derive from the Sydney region on the eastern coastal margin, where thermal conditions are milder than the average at that latitude. When morphology is viewed in relation to longitude, using 5 (20% percentile) categories, the bulk of the excess "stocky" reports fall in a single zone, 139°-149°E (Figure 35). While this includes Tasmania, it also includes virtually all of the southernmost part of the mainland (south of 35°S), as well as the Great Dividing Range except for the New England area. For "linear" descriptions, the maximum frequency falls in the most easterly zone, ≥150°E, which comprises much of the

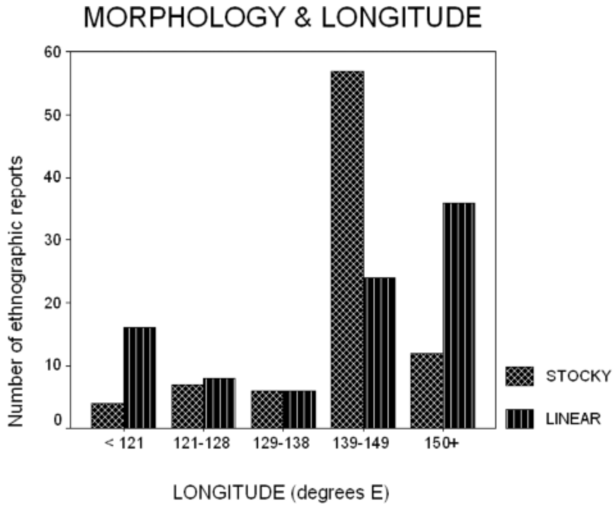



Figure 35 Morphology and longitude

eastern coastline. This may account in large part for a peak of "linear" descriptions in the 32-33.9°S latitude zone, which is exacerbated in this study by the high number of ethnographic reports from the Sydney region (151°E).

The wind chill results for morphology show a clear trend in relation to "linear" body build, declining with colder conditions and reaching a minimum in the coldest category (<10°C). While "stocky" descriptions peak in the middle (13-16.9°C) category, there is an overall trend of more frequent reports in the colder categories, with "stocky" descriptions outweighing "linear" in all the colder categories; the opposite is true for the two warmer categories. There may be an interaction with clothing, whereby increased use of clothes in the more southerly parts of the mainland reduces environmental selection pressure for morphological adaptations to cold, resulting in a maximum frequency of "stocky" descriptions in the middle wind chill zone.

Two discordant aspects of the clothing results warrant further comment. One relates to the gender differences, and the other to the seasonal pattern. As noted earlier, the Tasmanian clothing paradox appears to exist more for males than for females, and there is also a small increase in clothing for females in the most northerly zone that does not occur with males. The Tasmanian situation may be due in part to a general trend for Aboriginal females to be responsible for carrying any cloaks or rugs when tribal or family groups were on the move, and the likelihood that such items were themselves utilised as bags or containers. In Tasmania for instance, many early European observers (who had scheduled their visits to avoid the colder seasons) were of the view that the women used their capes more for carrying their infants and other items, rather than as protection from the cold. In other words, in regions where garments and rugs were in use, it was females rather than males who were more likely to be seen "wearing" these items when they were not being used for thermal protection. Judging by the descriptions of the garments themselves,

they were not discarded when not required for thermal use, but were retained (primarily by females?) until they had deteriorated to the point of no longer being serviceable. That thermal factors are implicated in the overall presence or absence of clothing is suggested by the latitudinal patterns, which pertain to females as well as males. Also, there is no physiological reason why females would need greater thermal protection than males. Lack of a clothing paradox for females in Tasmania may well reflect cultural influences, especially gender differences in responsibilities for carying the garments when not in thermal use. Moreover, the present study does not examine differences in the size and quality of the garments. It remains the case that large, heavy cloaks are described in the southeastern parts of the mainland, worn by both sexes, and such garments are conspicuously absent in Tasmania. The garments worn by Tasmanian women were less substantial than those worn by many of their female counterparts on the southern mainland. Even with a higher frequency of clothing reports for Tasmanian women, the clothing paradox probably exists for females when the type of garment is taken into consideration.

These issues may also be relevant to the lack of any seasonal differences in the distribution of clothing reports. Assuming that garments were not discarded when not required for thermal reasons – opossum-skin cloaks in particular required much effort to manufacture and were highly valued – such garments may be expected to be witnessed in all seasons in those areas where they were used. This should apply, however, more to females than males, but there are no seasonal differences for reports of clothing among males (Figure 36). Given the strong relationship between temperature and reports of clothing among males (Figure 37), the lack of any association with season in this study remains anomalous. In terms of sampling, the overall seasonal distribution of ethnographic reports does show a bias towards summer and autumn, and the numbers of cases for gender-specific clothing reports in each seasonal category are only modest.

The other anomaly occurs with respect to an increase in reports of clothing for females in the lowest latitude category, i.e. the northern zone. Perusal of the relevant ethnographic reports reveals a rather different type of garment to the animal skin draped across the shoulders that constitutes the typical mainland garment. In the case of females in the northern zone, the typical garment consists instead of a girdle or loin covering. In 1756 Gonzol, on the western coast of Cape York, described “females who had their privities covered with a kind of mats” (Heeres 1859: 94); in 1838 Stokes, in the Broome area, reported that some of the Aborigines (gender unspecified) “wear girdles of skin and leaves” (Stokes 1846: 88); MacGillivray in 1848 reported at Cape York that “grown up females usually wear a covering in front, consisting of a tuft of long grass... over this a short petticoat of fine shreds of pandanus leaf, the ends worked into a waistband, is sometimes put on, especially by the young girls” (Macgillivray 1852, II: 19-20).

The form of these garments, their lack of thermal or other utilitarian function, and their being confined largely to females, all point to a different situation to that which pertains in other parts of the mainland. They appear more as adornment or decoration and, while being generally inadequate for any purposes of modesty or genital covering, they hint at such a function. These considerations do not seem to apply, certainly not to the same extent, to the garments used by Aborigines elsewhere on the continent.

These northern Australian garments bear a marked resemblance to those worn in some adjacent areas further north, notably among females in parts of Papua New Guinea (e.g. Brown 1978: 48-49, Craig 1988: 14-17, Edmundson and Boylan 1999: 6-12). Such garments may represent, in other words, elements of a regional cultural sphere centred be-

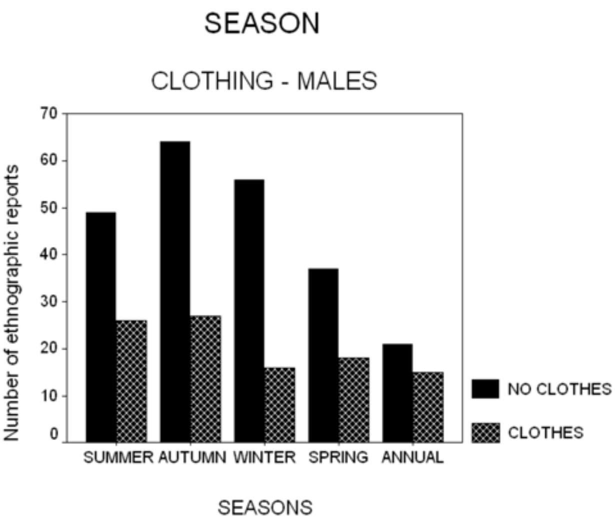



Figure 36 Males - “clothes” and season

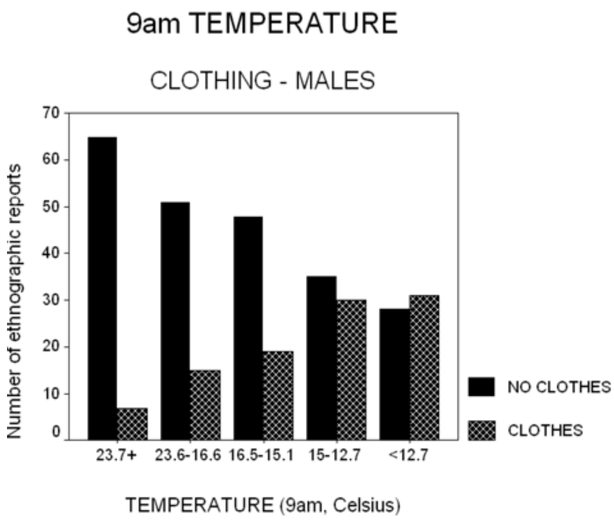



Figure 37 Males - “clothes” and 9am temperature

yond the mainland but which encompassed, however slightly or sporadically, northern areas of the Australian mainland. Similar items are documented, for example, along the lower Fly River in southern Papua New Guinea, among peoples speaking the Kiwai dialect. While both sexes may have more often went naked prior to European contact, and use of groin-shells or bark-cloth loin coverings among the men was not universal, the ethnographic record describes short "petticoats" (consisting usually of shredded sago or banana leaves suspended from a waist-belt) in frequent use among the women (Landtman 1917: 5, 1927: 23-24).

There may well have been some intermingling of peoples between Papua New Guinea and Cape York, among the islands in Torres Strait. While visiting the Murray Islands in 1822, Wilson observed people whom he considered had traveled from Papua New Guinea, "communication being easily effected by means of their large canoes, in the management of which they are extremely dexterous" (Wilson 1835: 313). Clothing among the local Torres Strait Islanders prior to European influence was generally restricted to females, with the exception of those who had not reached puberty, who usually went naked. The typical short "petticoat" was made from split leaves or beaten bark fibres, and, as in southern Papua New Guinea, the men might wear a similar garment or a groin-shell covering when dancing or fighting, or on other special or ceremonial occasions (Haddon 1912: 59-62).

There are also likely proto-historic contacts between northern Australian Aborigines and peoples from Southeast Asia. The most well known are the Macassans, who visited regularly, beginning probably in the seventeenth century (Macknight 1986). Aborigines sometimes even accompanied Macassans to their homeland and returned to Australia. At Port Essington in 1843 Jukes documents a *prahu* bringing an Aboriginal who had traveled to Sulawesi with the Macassans the previous year, this being apparently "not an uncommon occurrence, as the natives of Port Essington are very fond of going abroad to see the world" (Jukes 1847, I: 358-359). The presence of loin coverings and adornments in northern Australia, mainly among females, represents a major anomaly in the general pattern of clothing use in Aboriginal Australia. It may be a local phenomenon quite independent of any external influence, but the latter possibility cannot be discounted.

The use of girdles and loin coverings, restricted largely to parts of northern Australia, appears in the present study as the main example of the non-thermal use of clothing. In most cases it may be considered as a "cultural" use of clothing, although the addition of a small apron to the girdle sometimes worn by men has been attributed to a need to protect the genitals while walking in dense scrub (Wright 1979: 59). Other possible instances of the cultural use of clothing occur in southern zones, where European observers sometimes attributed the wearing of cloaks to social status. This was the case, for example, in the Port Phillip area. In the late spring of 1803, Pateshall reported that both males and females "go entirely naked excepting their Chiefs or Kings who wear Cloaks on their backs of small skins sewn very neatly together with grass" (Pateshall 1980: 60). This ascription of higher status to those wearing cloaks is, however, open to question. During the same visit of the *Calcutta*, Tuckey does not associate the use of opossum-skin cloaks with any differences in social status among the Aborigines, suggesting only that the cloak worn by the "chief" was "distinguished by its superior size" (Tuckey 1805: 175). During Murray's visit to Port Phillip and Western Port in early autumn the previous year, all the Aborigines were described as wearing animal skins or cloaks, and there are no distinctions in dress attributed to social status (Lee 1915: 109, Murray 2002: 28). During Baudin's April 1802 visit to Western Port, Faure observes that of the thirteen Aborigines seen all were "entirely naked", excepting one who "was covered with a black skin" – presumably an opossum-skin cloak (Péron 1809: 269). Flinders, who visited Port Phillip later that month, makes no reference either to nakedness or clothing in his description of the Aborigines (Flinders 1814: 219). When Europeans returned to begin a second attempt at settlement of the area in 1835, Batman accepted a gift of two cloaks from the "chiefs", and he added that the women generally "are clothed with cloaks of a description somewhat similar" (Batman 1835: 314). Robinson in 1836 observed simply that the Aborigines of Port Phillip "wear opossum rugs well sewed together with sinews from the kangaroo tails" (Plomley 1987: 408).

The evidence for any cultural use of clothing based on alleged social distinctions in this part of Australia is scanty. The possibility of such use of clothing should be noted, but interpreted in the context of the varying accounts. Also, the special nature of these earliest encounters between Aborigines and Europeans, and the conventions and expectations that affected the writing of reports, should be considered. Some observers may have expected to find "chiefs", and for these persons to be distinguished by their appearance or dress, and likewise the readers of such accounts at the time. The Aborigines, for their part, would have been cognizant of the Europeans' garments, and, given the sense of shock and potential threat that such situations were prone to elicit, the behaviour of their appointed representatives in negotiations with the visitors may have been far from typical, with a greater perceived need for formality and show than would pertain in meetings between members of neighbouring tribal groups, for example.

The cloaks and rugs described in the literature were often marked and decorated on the inside. However, not all the cloaks were so marked, and none of the garments used in Tasmania or south-western Australia appear to have been marked on the inside (Mountford 1963: 538). The common lozenge-shaped patterns incised on the inner surface of the larger garments may have served to render the skins more

flexible, while other figurative designs may have additionally denoted totemic meanings or personal ownership (ibid: 538-540). Most of the highly decorated cloaks and rugs date to the second half of the nineteenth century, and a number of observers have attributed the decorating of these items to a European influence. Dawson for example insisted that only the simple lines and lozenge-shaped markings, with the occasional addition of figures such as an outline of an emu in the centre, were used before the arrival of settlers (Dawson 1881: 9). Their colouring with ochre may also have become more widespread under European influence, although some colouring was probably practiced prior to white settlement (Wright 1979: 57). Notwithstanding the existence of cultural elements in the marking and colouring of cloaks and rugs, their geographical distribution, and the ethnographic descriptions of their use, have been interpreted as indicating an essentially thermal pattern for the use of such clothing in Aboriginal Australia (e.g. Howitt 1904: 40, Mountford 1960: 505).

Turning briefly to the ethnographic results for morphology, these show an increasing frequency of reports that have been coded as indicating a more "stocky" body build among Aborigines in southeastern Australia, and especially in Tasmania. As suggested earlier, such a trend may point to a possible resolution of the Tasmanian clothing paradox. The results may also point to the physiological importance of interactions between morphological and "cultural" adaptations. On the mainland, while reports of clothing reach a maximum in the higher latitude zones, the increasing frequency with latitude tends to plateau, and on some of the indices (e.g. the combined "naked - clothed" variable), the maximum clothing frequency occurs in the second-highest zone. In addition, morphology tends to show a small increase in reports coded as "stocky" in the lower latitude categories, with a minimum in the middle latitude zone. The differences are small, and may represent artefacts of the small sample sizes in each latitude category. It is possible, though, that these minor trends in morphology reflect the varying use of clothing, which may affect the need for morphological adaptation. The final balance between morphological and "cultural" adaptations to the prevailing thermal conditions in any particular area will depend upon a host of factors, including the relative severity of the extremes of heat and cold, and also longer-term considerations such as prior exposure to extremes during the late Pleistocene, as well as subsequent opportunities for genetic and cultural interchange between groups in different zones.

The ethnographic data on Aboriginal morphology utilised in the present study are, however, very limited and descriptive. Given its possible significance for the Tasmanian clothing paradox, there are other data sources bearing upon this issue which can provide additional and independent data. Physical anthropology in particular needs to be considered, both with respect to evidence for any mainland climatic trends in morphology and especially the available data for Tasmanian Aborigines.

## Conclusions

Each of the null hypotheses can be rejected on the basis of the findings in this ethnographic study, and the following conclusions may be drawn:

1. with certain exceptions and qualifications as outlined above, the distribution of reports of Aboriginal use of indigenous clothing on the mainland is consistent with a predominantly thermal pattern;

2. the Tasmanian clothing paradox is likely to be a real phenomenon;

3. thermal aspects of Aboriginal morphological variation may affect the patterns of clothing use, and in particular may be implicated in the Tasmanian clothing paradox.

Given these findings, the question of Aboriginal morphological variation with respect to thermal issues needs to be examined more thoroughly in considering a possible thermal basis for the Tasmanian clothing paradox. This will be the primary aim of Study 2. The third study, on the archaeological record of Tasmania, will examine human requirements for shelter during the late Pleistocene. This entails using the palaeoenvironmental record to reconstruct thermal conditions in the region, and these data may allow inferences as to the development of both morphological and "cultural" thermal adaptations in Aboriginal Tasmania.

# STUDY 2: MORPHOLOGY

## Chapter 7 Introduction and Method

### Introduction

Studies in physical anthropology have demonstrated consistent associations between environmental parameters and a number of major trends in human morphology. Body mass (or weight), body shape, head shape, and relative limb proportions for instance correlate with thermal conditions, particularly mean annual temperature. These trends exist on a global and on a continental or regional scale (e.g. Hiernaux 1963, Roberts 1978, Crognier 1981, Beals *et al.* 1983).

The associations between thermal and morphological variation are often cited as illustrating the operation of certain zoological "rules". One is Bergmann's rule, first stated in 1847 when Carl Bergmann noted the importance of the surface area to volume ratio in affecting heat balance:

> *Surface area is a simple and precisely determinable factor in heat loss...*
> *By contrast, the volume of the animal may be regarded as a measure of its possible heat production...*
> *Now it is not the case that the volume of bodies and their surface area increase and decrease in the same proportion, but rather, when, for example, we magnify every single dimension of a body in the relation of 1 to 2, then the surface area increases from 1 to 4 and the volume from 1 to 8.*
> *It is thus decided that the larger animals are, the less heat they must produce relative to their size in order to attain a certain elevation in temperature over their environment*
>
> (Bergmann 1847: 601)

A related principle is Allen's rule, refering more to the size of body appendages, with exposed limbs becoming shorter in cooler climates (Allen 1877). As Allen emphasised, such trends need not always result from alteration of genotype through natural selection, but can also arise from a direct influence of climate and other environmental factors on phenotypic development (ibid: 132).

In comparative studies of modern human groups, the Australian Aborigines emerge with a distinctly tropical pattern, i.e. a linear body build with relatively long, slender limbs (Roberts 1978: 22). Nonetheless, as mentioned in the main Introduction earlier, there are reasons for anticipating thermal trends in Aboriginal morphology. The reasons include the duration of their presence on the continent, and exposure to colder conditions during the late Pleistocene, especially in the southern regions and in Tasmania. The latter is especially relevant given palaeoenvironmental data indicating that the LGM was colder and more prolonged in the southern hemisphere than was hitherto believed (Lambeck and Chappell 2001, Lambeck *et al.* 2002, Turney et al 2004, Colhoun, pers. comm.).

The extent and interpretation of morphological variability within the Australian Aboriginal population has long been a central and even controversial issue (e.g. Thorne 1971). Debate has polarised between arguments favouring homogeneity on the one hand (e.g. Abbie 1975, 1976) and those emphasising heterogeneity on the other. Foremost among the latter is Birdsell, who has assembled copious data to support his "trihybrid" theory of Australian Aboriginal origins (Birdsell 1967, 1993). Most studies utilise cranial rather than post-cranial data, and aim to assess Aboriginal affinities in relation to other groups (e.g. Howells 1970, Habgood 1989, Wright 1992). Tasmanian Aborigines have been of special interest, and the results of cranial analyses favour a comparatively uniform Aboriginal morphology with little evidence of external affinities (e.g. Pardoe 1994).

In the Australian context, there has been little systematic investigation of whether Aboriginal morphological variation shows environmental patterning comparable to that seen in other human groups. Abbie, despite gathering valuable morphometric data, did not subject these to any environmental analysis (e.g. Abbie 1975: 76-95). A reanalysis by other workers, using three of his tribal samples from northern, central and southern central Australia, found significant regional variation in head and body measurements and indices (Macho and Freedman 1987: 22-25). When examined in relation to climatic indices (summer maximum and winter minimum temperatures, temperature ranges, summer and winter relative humidity, and rainfall), multiple stepwise regression analyses revealed that climatic factors made a generally small but statistically significant contribution to variation in most of the head and body measurements (ibid: 44-54). Head breadth and circumference, facial breadth, nasal shape, stature, limb lengths, relative sitting height, and ponderal index, all showed significant trends on at least some of the climatic indices. The authors urged caution in interpreting these results, although they suggested that the most important climatic variable overall appeared to be the temperature range of the coldest month (ibid: 53-54). It can be noted, however, that these analyses utilised morphometric data from only six Aboriginal groups, three of which were from northern Australia (the Kimberly and Arnhem areas), and the "southern" (Yalata) sample had originated in northern South Australia, in close proximity to the two central Australian samples. As a consequence, the geographical sampling was limited, and this applies also to the corresponding climatic data.

Like Abbie, Birdsell grants scant attention to climatic factors (e.g Birdsell 1993: 316, 450-451). Yet many of his "clinal topographies" of morphological variation bear striking similarities to meteorological maps of Australia, and clearly invite such an approach. Birdsell's data base is nonetheless exhaustive, and it provides a wealth of post-cranial data along with other non-metric data which are

generally lacking in other studies. Post-cranial data, especially indices relating to limb proportions and linearity of body build, are of particular interest in assessing possible correspondences between morphological and climatic variation. His data are derived largely from the examination of living tribal groups, with some osteological data included, mainly in the craniofacial measures. Additional osteological post-cranial data are available from other studies and, together with Birdsell's data, are amenable to environmental analyses. However the geographical provenance of the osteological material is often imprecise, limiting its value for this purpose. Another problem is the paucity of morphometric and osteological data for the Tasmanian Aborigines.

Osteological data are relevant not only for examining environmental trends *per se*, but also the evidence for more "robust" Aboriginal morphology in the late Pleistocene. One view is that, in the Australian context at least, skeletal robusticity may reflect a morphological response to environmental conditions (Bulbeck *et al.* n.d.: 2, Stone 2004: 20). If so, it parallels the situation in ice age Europe, and may account for the reduced robusticity in Australia associated with climatic amelioration during the Holocene. Compared to other modern human groups, the post-cranial osteology of Australian Aborigines indicates gracility rather than robusticity, reflecting the generally high mean temperatures in post-glacial Australia (Collier 1989: 26). Data such as relative limb segment lengths, and measures of body shape such as the claviculo-humeral index, would assist in distinguishing between competing hypothetical scenarios. A climatic model predicts that robusticity should be associated with reduced limb proportions, as applies with Neanderthals. Conversely, any robusticity associated with archaic hominid morphology such as late Pleistocene *Homo erectus* in Southeast Asia (e.g. Swisher *et al.* 1994) should be accompanied by more tropical limb proportions.

Among fossil hominids, indices of body shape and limb proportions show correlations with thermal conditions (e.g. Ruff 1991, 1994, Holliday and Falsetti 1995). For example, the brachial and crural indices of "cold adapted" Neanderthals are in the lower range compared with both early and contemporary *Homo sapiens sapiens*, and the indices are lower among European than Near Eastern Neanderthals (Trinkaus 1981: 189-209). A similar trend is evident in the claviculo-humeral index (ibid). For the latter, a high index is an indicator of a more stocky body build. It is greater in Neanderthals compared with modern humans in late Pleistocene Europe, and also in European compared with Near Eastern Neanderthals. There is a marked discontinuity between Neanderthal and early modern humans in Europe in terms of limb and trunk proportions, with fully modern humans subsequently showing a temporal trend over some 20,000 years from tropical to more temperate body proportions (Holliday 1997). The retention of tropical limb proportions among fully modern humans in Europe during the LGM may be attributed to "improved cultural buffering" (ibid: 442) which, for reasons of thermal physiology, included tailored, multi-layered garment assemblages (Gilligan and Walker n.d.). With regards to head size and shape, a trend to larger and rounder heads is a general feature of hominid evolution associated with brain expansion and the adoption of an erect posture (Weidenreich 1945), with a further likely effect of cold adaptation among more recent hominids throughout the Pleistocene (Beals *et al.* 1983).

With respect to environmental measures, most studies have been limited to temperature, mainly mean annual temperature. However, environmental adaptations and responses will reflect exposure to the monthly and diurnal ranges, especially maximum and minimum temperatures. Environments having similar mean annual temperatures can be very different in terms of thermal extremes, but it is the latter that will have most influence on any morphological variation. As an example, southern Africa and central Australia share similar latitudes and mean annual temperatures, but diurnal and seasonal variation is more marked in Australia. Comparing Durban (29°50'S, mean annual temperature 20.6°C) and Alice Springs (23°38'S, annual mean 20.9°C), Durban's minimum recorded July temperature is 3.9°C whereas Alice Springs' is -7.2°C - despite Durban having a slightly higher latitude and lower mean annual temperature (data from Lamb 1972: 542-543). Morphological attributes that vary in relation to warm or cold conditions may show different trends in these two regions, despite similar mean annual temperatures. For this reason, the present study uses average yearly minimum and maximum temperature in addition to mean annual temperature. Where the latter correlates with morphological variation, the use of maximum and minimum measures may help to reveal whether the trend reflects exposure to warmer or cooler extremes.

Other environmental parameters of interest are moisture (e.g. humidity and rainfall), solar radiation levels, and the wind chill effect. The latter for instance has been implicated as a factor in the stocky body shape of Polynesians. Their relatively large body mass, thick limbs, round heads and reduced surface area to volume ratio would appear better adapted to higher latitudes, rather than a tropical Pacific habitat. However despite mild mean temperatures, their oceanic environment entails exposure to wind chill exacerbated by evaporative cooling due to high moisture levels, resulting in high rates of heat loss and the risk of hypothermia (Houghton 1990).

In physiological terms, wind chill is more crucial than average or even minimum temperatures in assessing thermal requirements. Moisture will affect rates of heat loss, and hence the effectiveness of thermal adaptations, morphological and cultural. Also, the level of solar radiation – as determined by factors such as latitude, cloud cover and average hours of sunshine – will affect the net heat load. For these reasons, it is advisable to examine a representative range of environmental variables.

The combined effect of the major climatic variables such as air temperature, humidity, wind velocity and solar

radiation can be estimated as the "apparent temperature", or AT (Steadman 1984). This index was developed in Australia and has been applied internationally, and maps of AT indicate that much of Australia is more temperate than is suggested by dry-bulb temperatures (Steadman 1994). Although intended mainly to measure thermal comfort, AT can provide a quantitative approximation for the combined impact of these variables on human physiological requirements and the development of thermal responses, including morphological adaptations.

## Aims

This study aims to investigate whether trends in morphological variation among Australian Aborigines correlate with environmental parameters, primarily by subjecting the Birdsell data base to a re-analysis using meteorological indices. It aims also to augment existing international studies on environmental trends in human morphology by examining an extensive range of morphological and environmental data within Australia. Post-cranial osteological evidence from Tasmania, while limited, is analysed and compared with data from the mainland Australian Aboriginal population and also other modern human groups. These results, in combination with those from the re-analysis of Birdsell's morphometric data, may provide an indication as to whether Australian Aborigines in general, and Tasmanian Aborigines in particular, manifested morphological adaptations to their thermal environments.

## Materials and Methods

### Morphological data

Included in the present study are all the quantified data on Australian Aborigines presented by Birdsell (1993). In addition to measures and indices relating to body form, the cranium, and limbs, are variables relating to features such as skin colour and hair form, amounting to 124 variables in total, as well as serological data (12 variables) and dental data (50 variables). Most of these data were obtained from surveys conducted in 1938-1939 and 1952-1954 among over two thousand individuals, along with data collected during the University of Adelaide expeditions and by a number of other workers. The data comprise mean tribal values. The number of individuals examined in each group ranges from as few as 5 or 6 to over 100, with an average of 67 for the 28 "basic" tribes in the northwest. Also included are osteological data on crania examined in various institutions. While the whole continent is covered, data on most of the body and especially the limb measures are less comprehensive, with a marked sample bias towards tribes from the northwestern region.

Osteological data are obtained from published and unpublished sources (e.g. Rao 1966:139-149, Collier 1989: 28, Donlon 1990: 291-399, Bennett 1995: 108-112). Post-cranial data for Tasmanian Aborigines are included, consisting of limb measures and indices and the claviculo-humeral index. Tasmanian Aboriginal data are compared with their mainland counterparts and with data for other modern human groups, and also with late Pleistocene and early Holocene populations in Europe (Trinkaus 1981).

### Environmental data

Nine environmental variables are used in the analysis. As in Study 1, the first seven are derived from climatic data available on the Australian Bureau of Meteorology's website, based on 30-year averages (1961-1990) for numerous weather stations. While data derived from longer recording periods exist for some locations, only the 30-year averages are used here for reasons of consistency, as more extensive records are not available for remote stations in areas corresponding to some of the tribal distributions. Three temperature averages are used, as mean annual temperature alone will not distinguish between any differential effect of low or high seasonal average temperatures. Meteorological data from a total of 78 weather stations are used in the Birdsell re-analysis. The indices, and the abbreviations used in factor analyses, consist of:

1. average daily sunshine (hours), annual [SUN];
2. mean temperature (Celsius), 50th percentile, annual [TMEAN];
3. minimum temperature (Celsius), 50th percentile, annual [TMIN];
4. maximum temperature (Celsius), 50th percentile, annual [TMAX];
5. average daily relative humidity (%), 9am, annual [HUMID];
6. rainfall (mm), 50th percentile, annual [RAIN];
7. wind velocity (km/hr), mean monthly 3pm, annual average [WIND];
8. wind chill (Steadman formula), average annual 3pm temperature (Celsius) and wind velocity (km/hr);
9. apparent temperature (Celsius), average of January and July normal apparent temperature at solar noon.

Wind-chill is not calculated routinely by the Australian Bureau of Meteorology. As discussed in Study 3, true average wind-chill indices require simultaneous measures of air temperature and wind velocity, and these data are not available for most of the weather stations. What are available are average monthly air temperatures and wind velocities, which can provide proxy measures of average wind chill. While this is not ideal, the error associated with average wind-chill figures derived from daily and weekly averages is as low as a few percent, compared to averages calculated using simultaneous air temperature and wind velocity data (Court 1948).

Wind-chill data are based on the 30-year average July and annual temperature and wind velocity data provided by the Bureau of Meteorology for each of the weather stations. Calculations were performed using the wind chill calculator at the Meteonet website as in Study 1.

Apparent temperature data are extracted from the maps of normal Apparent Temperature in Australia for January and July (Steadman 1994), with the average of the two being used in the analyses.

Intercorrelations between the nine environmental variables are shown in Table 16. Sunlight does not correlate with any other indices. Mean annual temperature correlates with minimum and maximum temperatures, although the minimum and maximum measures themselves are not associated. The two moisture variables (relative humidity and annual rainfall) correlate with each other; humidity also correlates negatively with maximum temperature and the wind measures. In addition to expected correlations with wind chill and apparent temperature, average wind velocity correlates with low humidity. Wind chill correlates with average maximum temperature, which may be partly an artefact of comparatively high Australian temperatures increasing the index even for modest wind speeds. Apparent temperature correlates with most of the other variables, with only maximum temperature and rainfall failing to show a correlation. Overall, aside from strong correlations among the three main temperature variables and between the two moisture variables, the environmental variables used in this study emerge as relatively independent parameters.

The problem of intercorrelations, or multicolinearity, between the environmental variables, is one reason why a single regression analysis for each morphological variable on each environmental variable may be preferred over multiple regression analysis, at least at a preliminary stage of data analysis. In conjunction with the above table of intercorrelations, it also has the advantage of showing where multiple environmental correlations for a particular morphological variable are independent effects, as occurs for instance when skin colour correlates with both sunshine and mean temperature.

The tribal distributions correspond to those given in Birdsell (1993), with reference to Tindale (1974) where clarification was required. For each tribal group (or groups, where pooled tribal data are used by Birdsell), a weather station is identified as close as practicable to the centre of the tribal or pooled tribal territory. Compromise is occasionally necessary, especially where climatological data are incomplete at the most central station (as is sometimes the case for wind velocity data), in which case another station with a full data set within the tribal boundaries is selected. Some of the tribal boundaries encompass extensive areas, especially the pooled series. This applies for instance with the Southern Hinterland pooled series (P-G), where the Coober Pedy weather station is utilised, although its

| | sunshine (daily hrs) | mean temp. (°C) | minimum temp (°C) | maximum temp (°C) | relative humidity | rainfall (mm.) | wind velocity | wind chill | Apparent Temp. |
|---|---|---|---|---|---|---|---|---|---|
| sunshine (daily hrs) | – | | | | | | | | |
| mean temp. | .0125<br>p = .886 | – | | | | | | | |
| minimum temp.. | -.0934<br>p = .283 | **.4287**<br>p = .000 | – | | | | | | |
| maximum temp. | .0954<br>p = .273 | **.4140**<br>p = .000 | .0321<br>p = .713 | – | | | | | |
| relative humidity | -.1579<br>p = .068 | .0143<br>p = .870 | .0247<br>p = .777 | **-.3088**<br>p = .000 | – | | | | |
| rainfall (mm.) | -.1929<br>p = .026 | -.0127<br>p = .884 | .1623<br>p = .061 | -.0505<br>p = .562 | **.6368**<br>p = .000 | – | | | |
| wind velocity | -.0144<br>p = .868 | -.0005<br>p = .995 | .0960<br>p = .270 | .0009<br>p = .992 | **-.3449**<br>p = .000 | .1293<br>p = .136 | – | | |
| wind chill | .0566<br>p = .516 | .0828<br>p = .341 | -.0207<br>p = .813 | **.3491**<br>p = .000 | -.2117<br>p = .014 | .0792<br>p = .363 | **-.6161**<br>p = .000 | – | |
| Apparent Temp. | .1823<br>p = .035 | **.2709**<br>p = .002 | **.3566**<br>p = .000 | .1288<br>p = .138 | **.2207**<br>p = .000 | .1428<br>p = .100 | .1974<br>p = .022 | **.2814**<br>p = .001 | – |

(bold type = significant at .001 level)

Table 16 Correlation matrix – environmental variables

climatic data will not necessarily typify average environmental conditions throughout the whole region. Similarly, the Southeast Coast area (B-11) covers a range of environmental conditions for which climatic data from the selected station (Merimbula) are only an approximate indicator. However, relative rather than absolute differences over a continental range are most relevant in this study and, despite its limitations and compromises, the methodology should be capable of detecting large-scale environmental patterning in the morphological data.

**Statistical analyses**

A bivariate Pearson correlation coefficient (*r* value) is calculated for each morphological variable on each of the nine environmental variables, using SPSS® Graduate Pack 11.0 for Windows. This simple but powerful exploratory statistic is suitable for detecting the predicted linear relationships (Moore 2004: 88-94). Histograms show that the distribution frequencies for dependent (morphological) variables are acceptable, in most cases approximating normal distributions. The environmental variables however are skewed, as they are tied to the tribal distributions. This reflects a sampling bias in most of Birdsell's data towards the northwestern corner of the continent, which may reduce the likelihood of detecting large-scale environmental associations. Tests for significance are two-tailed; one-tailed tests are also performed where results approach significance and there exist clear expectations of trends occurring in a certain direction (e.g. between humeral length and minimum temperature). Statistical significance is given at the 0.05 and 0.01 levels. Linear regression analysis was performed for each morphological (dependent) variable on each environmental (independent) variable. The $r^2$ value is expressed as a percentage estimate of the total variance attributable to the independent variable. Scatterplots are prepared for each analysis, and a regression line fitted. Figure 38 is an example, illustrating all the environmental results for one morphological variable (femoral length).

Factor analyses are also performed for the seven basic environmental variables and for selected morphological variables, along with regression analyses to examine for correlations between the resulting environmental and morphological factors. An advantage of factor analysis is that correlations between variables are extracted with each factor, so the factors themselves are independent of each other, regardless of any original correlations between the variables.

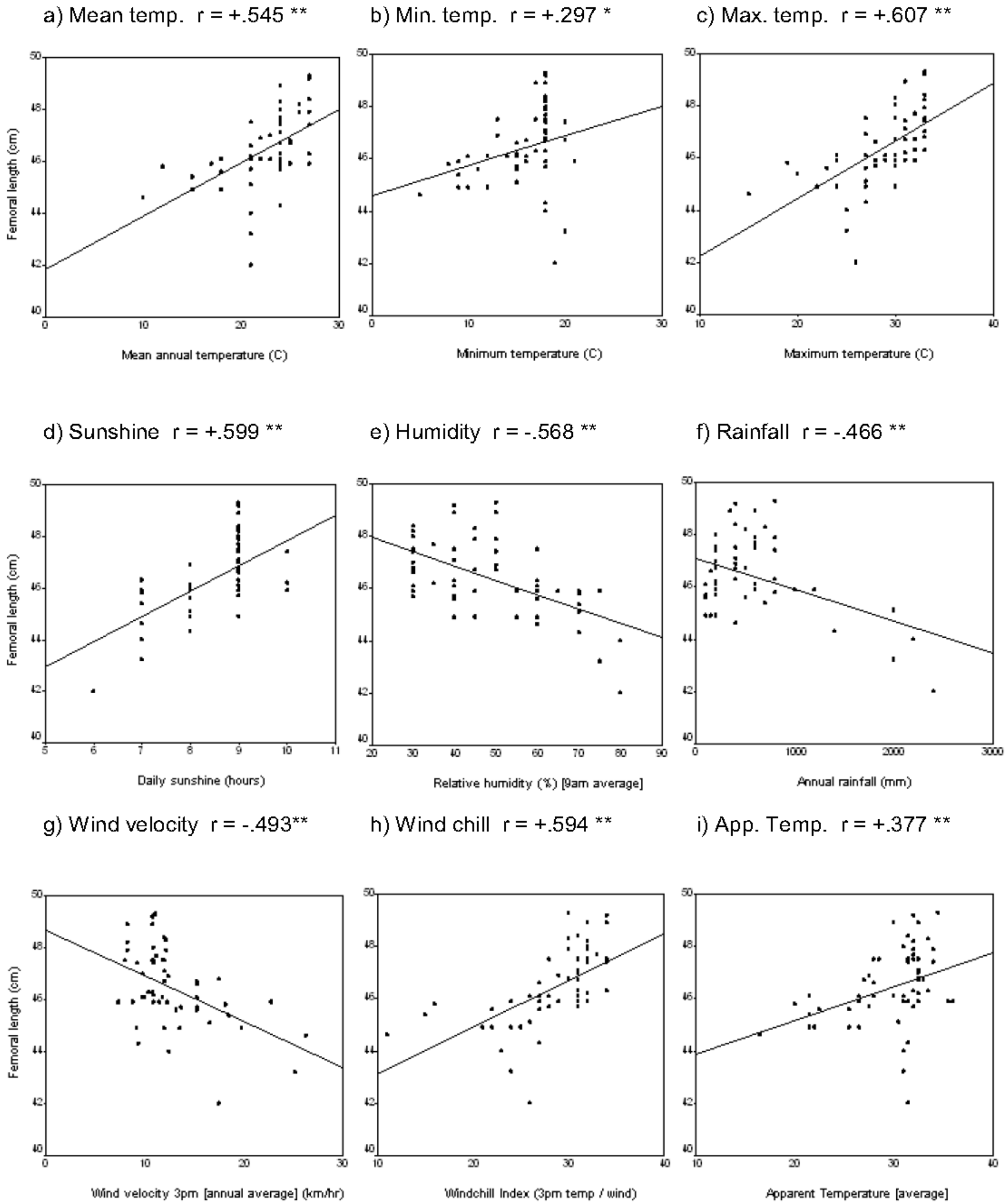



Figure 38 Femoral length: environmental correlations – all variables

# Chapter 8 Results and Discussion

## Results

### Correlation coefficients

Pearson correlation coefficients for each dependent variable on each of the nine environmental variables are tabulated in Appendix A2 (on the accompanying CD). Dependent variables have generally been grouped as they appear in Birdsell (1993), and page references are given. Also shown is the source of the tribal data (Birdsell's own surveys, or those of Birdsell plus other workers), together with the total number of tribal groups in each analysis, and whether any data from Tasmanian Aborigines are included. The proportion of the total Australian land mass (including Tasmania) covered by the tribal populations sampled on each variable is estimated to the nearest 5%, and it varies between 20% and 95%. Correlation results for all 186 of Birdsell's variables, including dental and serological variables, can be found in Appendix A2; results for selected morphological variables are shown in Table 17.

*(i) pigmentation:*

Darker skin colour correlates with sunlight, but there is a stronger association with temperature. A thermal association is also suggested by the negative correlation with wind velocity (i.e. a lighter skin colour in cooler, windier areas) and also the correlation with apparent temperature (Figure 39). Oral pigmentation shows an opposing pattern and has strong negative scores on these variables, sunlight included. Tawny or blonde hair, more common in the western desert areas, correlates with low moisture levels. Eye (iris) colour among Australian Aborigines is brown, albinism excepted (Walker 1969), but Birdsell found its intensity varies markedly; this variation however does not correlate with environmental variables.

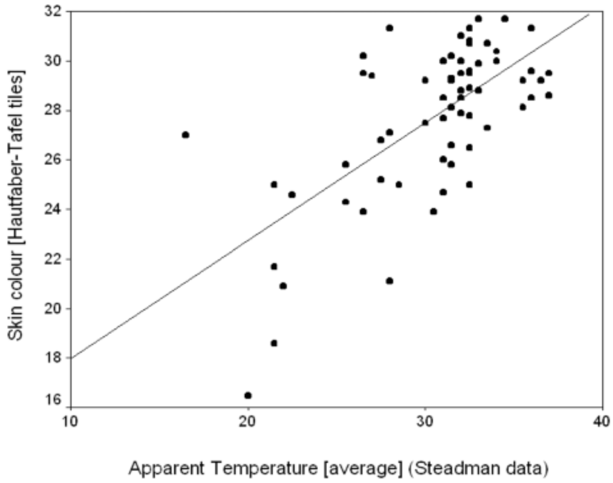



Figure 39 Skin colour and Apparent Temperature

*(ii) hair:*

Body and facial hair are more pronounced in cooler, windier and drier regions (e.g. Figure 40). Minor hair variables (e.g. nostril and finger hair) show lower correlations with temperature, and none with moisture. Scalp hair presents a distinctive picture, with curled hair correlating with moisture (Figure 41). Grey head hair occurs at an earlier age in hotter regions, and male baldness increases in cooler regions. Environmental correlations are less evident for patterning in scalp hair such as the direction of whorls. The last hair feature, circumcaruncular hair, occurs on the inner borders of the eyelids but is distinct from eyelashes, and it correlates with cooler, windier and drier conditions.

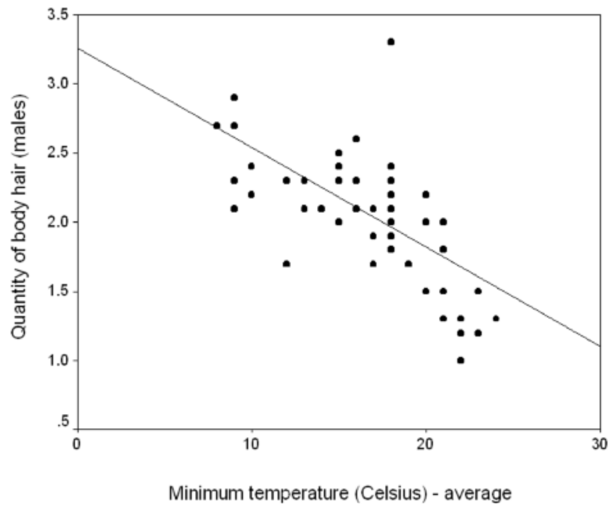



Figure 40 Body hair and minimum temperature

*(iii) other non-metric variation:*

This category covers a disparate range of features (e.g. left-handedness, and relative size of upper and lower lips) which are generally poorly correlated with environmental variation. Alveolar prognathism is more pronounced in cool, windy

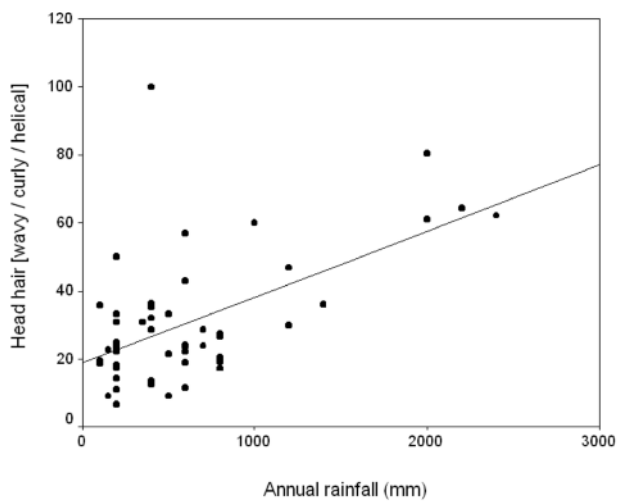



Figure 41 Curled head hair and rainfall

| variable Birdsell '93 reference | *tribal data* | Nº of tribes Tasmania ± area estimate | | sun-light (hours) | mean temp. (° C) | min. temp. (° C) | max. temp. (° C) | relative humid. (%) | rain-fall (mm.) | wind velocity (km/hr) | wind chill (Steadman) | App. Temp (Steadman) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| skin | | 65 | r | +.388 | +.705 | +.656 | +.713 | -.290 | -.031 | -.322 | +.686 | +.663 |
| colour | Birdsell | T+ | $r^2$ | 11.4% | 49.7% | 43.0% | 50.8% | 8.4% | 0.1% | 10.4% | 47.1% | 44.0% |
| 185-189 | + others | area ≈70% | s | ** | ** | ** | ** | */** | - | ** | ** | ** |
| body hair | | 64 | r | -.548 | -.499 | -.649 | -.288 | -.422 | -.497 | +.232 | -.299 | -.584 |
| quantity | Birdsell | T- | $r^2$ | 30.0% | 24.9% | 42.1% | 8.3% | 19.5% | 24.7% | 5.4% | 8.9% | 34.2% |
| 210-211 | + others | area ≈65% | s | ** | ** | ** | * | ** | ** | -/* | */** | ** |
| head hair form | | 57 | r | -.346 | -.129 | +.068 | -.292 | +.425 | +.569 | +.392 | -.237 | +.016 |
| (wavy) | Birdsell | T+ | $r^2$ | 11.9% | 1.7% | 0.5% | 8.5% | 18.1% | 32.4% | 15.3% | 5.6% | 0.0% |
| 216-219 | | area ≈75% | s | ** | - | - | * | ** | ** | ** | -/* | - |
| prognathism | | 37 | r | -.356 | -.457 | -.463 | -.526 | -.380 | -.617 | +.313 | -.337 | -.634 |
| -alveolar | Birdsell | T- | $r^2$ | 12.7% | 20.8% | 21.5% | 27.7% | 14.5% | 38.0% | 9.8% | 11.4% | 40.2% |
| 275-278 | | area ≈30% | s | * | ** | ** | ** | * | ** | -/* | * | ** |
| stature | | 93 | r | +.509 | +.504 | +.333 | +.543 | -.341 | -.272 | -.462 | +.540 | +.406 |
| (males) | Birdsell | T+ | $r^2$ | 25.9% | 25.4% | 11.1% | 29.5% | 11.7% | 7.4% | 21.3% | 29.1% | 16.5% |
| 308-311 | + others | area ≈95% | s | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| femoral | | 57 | r | +.599 | +.545 | +.297 | +.607 | -.568 | -.446 | -.493 | +.594 | +.377 |
| length | Birdsell | T- | $r^2$ | 35.9% | 29.7% | 8.8% | 36.9% | 32.3% | 19.9% | 24.3% | 35.3% | 14.2% |
| 426-427 | | area ≈ 65% | s | ** | ** | * | ** | ** | ** | ** | ** | ** |
| ponderal | | 86 | r | +.268 | +.539 | +.556 | +.463 | -.096 | +.127 | -.303 | +.450 | +.530 |
| index | Birdsell | T- | $r^2$ | 7.2% | 29.0% | 30.9% | 21.4% | 0.9% | 1.6% | 9.2% | 20.3% | 28.1% |
| 313-316 | + others | area ≈ 90% | s | ** | ** | ** | ** | - | - | ** | ** | ** |
| rel. shoulder | | 75 | r | -.243 | -.605 | -.551 | -.585 | +.158 | +.024 | +.435 | -.593 | -.541 |
| breadth | Birdsell | T- | $r^2$ | 5.9% | 36.6% | 30.4% | 34.2% | 2.5% | 0.1% | 18.9% | 35.1% | 29.2% |
| 316-318 | + others | area ≈ 90% | s | * | ** | ** | ** | - | - | ** | ** | ** |
| intermembral | | 56 | r | -.237 | -.585 | -.457 | -.497 | +.378 | +.124 | +.356 | -.575 | -.419 |
| index | Birdsell | T- | $r^2$ | 5.6% | 34.2% | 20.9% | 20.9% | 14.3% | 1.5% | 12.7% | 33.1% | 17.5% |
| 325-326 | | area ≈ 65% | s | -/* | ** | ** | ** | ** | - | ** | ** | ** |
| nose | | 75 | r | +.327 | +.308 | +.135 | +.525 | -.483 | -.315 | -.122 | +.456 | +.278 |
| breadth | Birdsell | T- | $r^2$ | 10.7% | 9.5% | 1.8% | 27.5% | 23.3% | 9.9% | 1.5% | 20.8% | 7.7% |
| 369-372 | + others | area ≈ 90% | s | ** | ** | - | ** | ** | ** | - | ** | */** |
| cranial | | 93 | r | -.138 | -.438 | -.504 | -.355 | -.113 | -.351 | +.173 | -.320 | -.437 |
| module | Birdsell | T+ | $r^2$ | 1.9% | 19.2% | 25.4% | 12.6% | 1.3% | 12.3% | 3.0% | 10.3% | 19.1% |
| 380-383 | + others | area ≈ 85% | s | - | ** | ** | ** | - | ** | -/* | ** | ** |
| cephalo-facial | | 104 | r | +.535 | +.613 | +.580 | +.612 | -.325 | -.049 | -.417 | +.593 | +.607 |
| index | Birdsell | T+ | $r^2$ | 28.6% | 37.5% | 33.7% | 37.4% | 10.6% | 0.2% | 17.4% | 35.2% | 36.8% |
| 394-397 | + others | area ≈ 95% | s | ** | ** | ** | ** | ** | - | ** | ** | ** |

key:
- r = Pearson correlation coefficient
- $r^2$ = estimate of total variance %
- s = significance: * < 0.05 (2-tailed) /* < 0.05 (1-tailed); ** < 0.01 " /** < 0.01 "

Table 17 Birdsell re-analysis: selected correlation results

and dry conditions (Figure 42), and brow ridges are a little larger in warmer and sunnier regions. Parietal sagittal elevation correlates strongly with cool, dry and windy conditions, showing a negative correlation (-.658) on Apparent Temperature. Parietal bosses correlate with moisture. Cryptose iris structure, a degenerative eye condition, is related most strongly to intensity of solar radiation, while interrupted contraction furrows of the iris occur more commonly with higher temperatures.

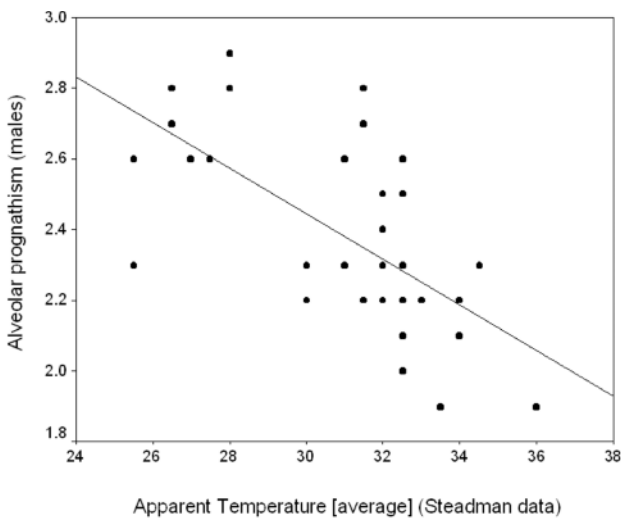



Figure 42 Alveolar prognathism and Apparent Temperature

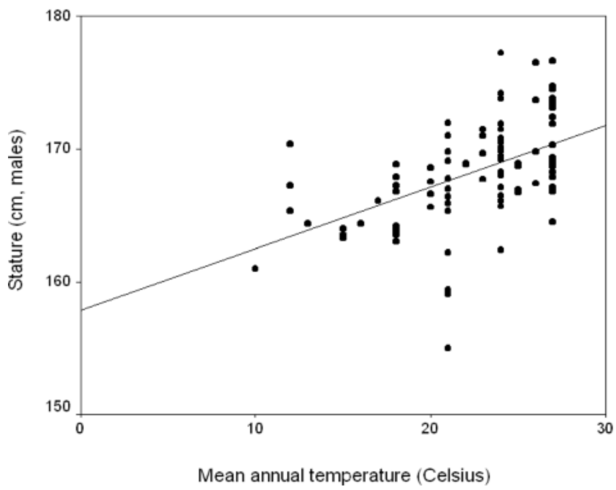



Figure 43 Stature and mean annual temperature

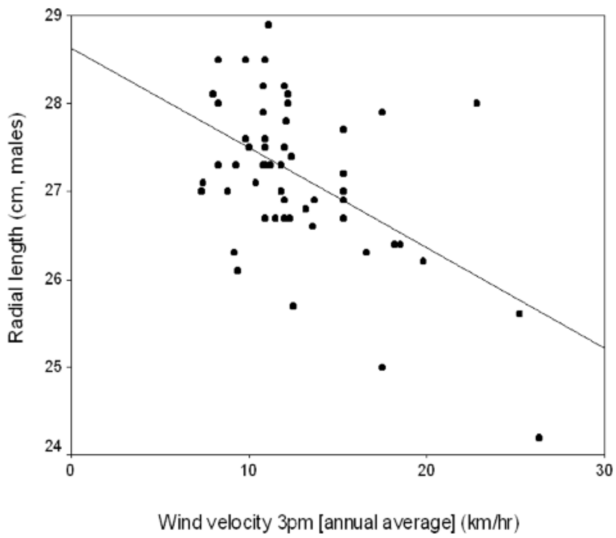



Figure 44 Radial length and wind velocity

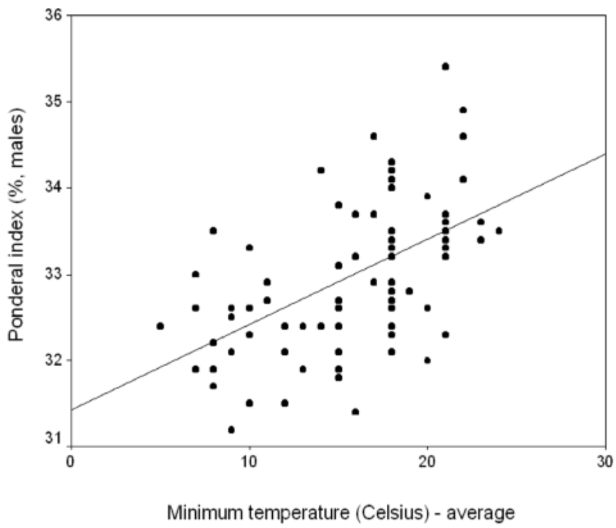



Figure 45 Ponderal index and minimum temperature

*(iv) body and limb metrics*

Body weight (or mass) does not correlate with temperature, though it does increase in drier and sunnier conditions. Stature correlates with all of the environmental variables, especially temperature, and is reduced in windy and dry conditions (Figure 43). Shoulders tend to be a little broader in sunnier and drier areas, and where winter temperatures are cooler. Sitting height correlates positively with sunlight and with the temperature measures, and negatively with wind velocity. Limb length measures show strong environmental correlations - positive for temperature and sunlight, negative for moisture and wind velocity (e.g. Figure 44).

*(v) body and limb indices*

The ponderal index (stature ÷ cube root of weight) is one of the most commonly-used measures of overall body shape. In this analysis, a more linear build is seen to occur with higher average temperatures, especially higher average minimum temperatures, i.e. milder winters (Figure 45); a more stocky build is seen in cooler and windier conditions. Relative shoulder breadth likewise shows a strong thermal effect, with a broader body shape occurring in cooler and windier regions and, to a lesser extent, less sunny areas. Relative sitting height (trunk length relative to stature) follows the predicted negative thermal trend but not strongly, and shows stronger correlations on moisture and sunlight variables. For the limb indices, all show strong thermal correlations, with the exception of the radial-humeral index, which barely reaches significance. Most of the limb-body indices correlate more with low moisture and high sunlight than with temperature, suggesting a coastal *v.s.* inland effect, at least in the south-east. The tibial-sitting height and, to a lesser extent, the radial-sitting height indices correlate with high maximum temperatures.

*(vi) head and facial metrics*

Head length and breadth correlate negatively with temperature variables, whereas basal head breadth correlates negatively with moisture variables, especially low rainfall (Figure 46). Head height does not correlate with environmental variables. Total facial height correlates negatively with temperature, though not strongly. Like basal head breadth, measures of lower facial breadth correlate with high sunlight and low moisture, conditions which may correspond to more inland locations. Nasal breadth correlates with humidity (Figure 47), and also with higher maximum temperatures. Nose height and depth show fewer environmental correlations; nasal height increases somewhat in sunnier and less windy conditions, while nasal depth is greater where minimum temperatures are lower. Lips are thicker where environmental moisture levels are high; narrow lips, on the other hand, result in less exposure of the moist lip surfaces, reducing total moisture loss in drier environments. Mouth breadth, however, is notable in being correlated with dry and sunny conditions, and also high maximum temperatures. This may suggest a thermal advantage of greater mouth width (where lips are narrow to conserve moisture), perhaps in terms of greater cooling capacity. These data are for mainland Aborigines only: Tasmanian data would be useful for exploring possible interacting temperature and moisture effects, but none are available.

*(vii) head and facial indices*

The cranial module, an index of overall cranial size, increases as temperatures fall, especially minimum temperatures, and to some extent in drier and more windy conditions, and it correlates negatively with apparent temperature (Figure 48). Scores on the temperature and wind variables for the cephalic index are less strong but still reach statistical significance. The basal breadth index (basal breadth ÷ parietal breadth) correlates with sunlight and low moisture and, to a lesser extent, with milder winter temperatures and less windy conditions. Most of the other cranial and cranio-facial indices show environmental correlations. The cephalo-facial index is noteworthy for its "historical" place in arguments regarding Aboriginal homogeneity (ibid: 394); it shows marked variability which correlates with environmental indices, especially temperature and wind variables (Figure 49). Among the facial indices, total facial index (breadth ÷ height) correlates mainly with humidity but also with lower temperatures and reduced sunlight. The nasal breadth and depth indices correlate most with humidity and low minimum temp-er-atures respectively.

*(viii) composite gradients*

These are of limited use in this study. They are calculated on the number of clinal isophenes separating neighbouring tribes, and are used by Birdsell as an indirect measure of the "biological differentiation" within the Aboriginal population

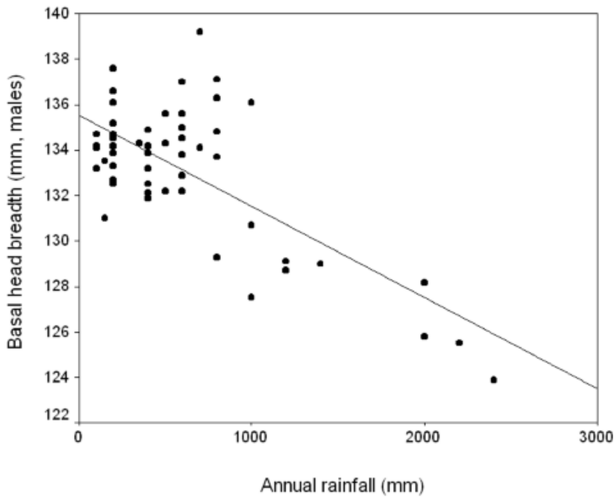



Figure 46 Basal head breadth and rainfall

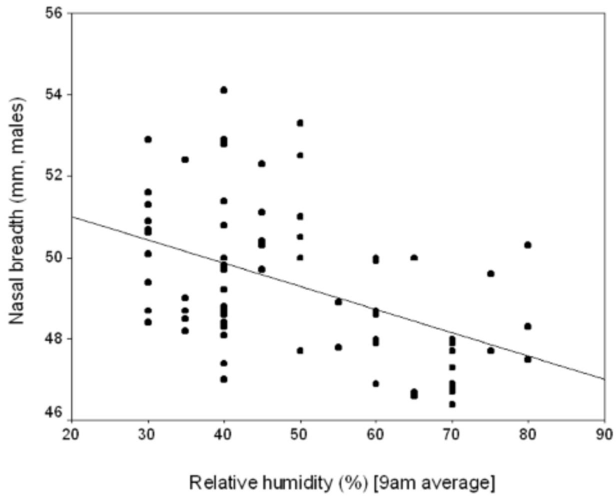



Figure 47 Nasal breadth and relative humidity

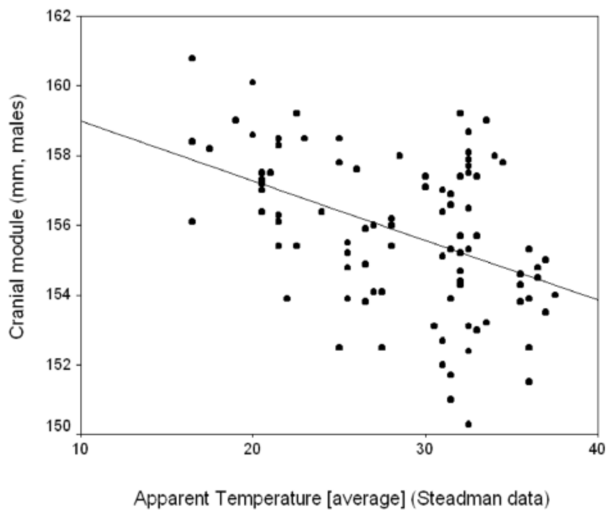



Figure 48 Cranial module and Apparent Temperature

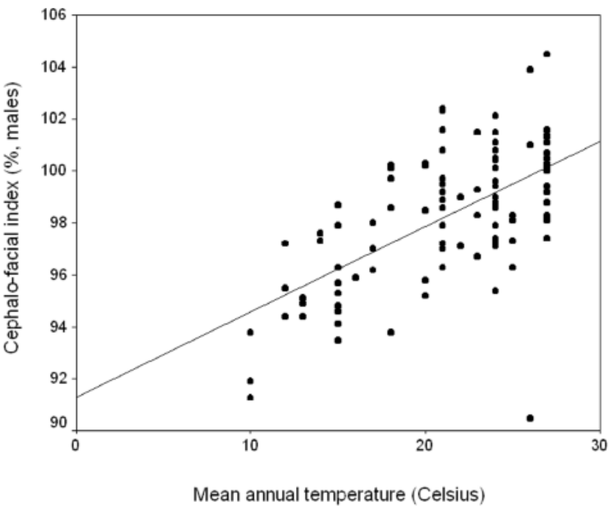



Figure 49 Cephalo-facial index and mean annual temperature

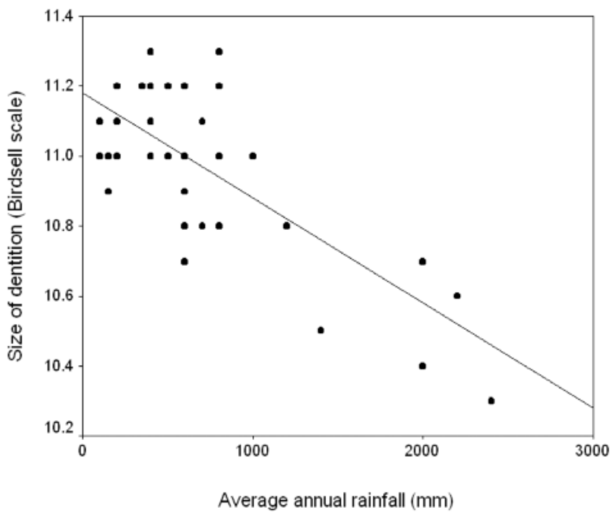



Figure 50 Size of dentition and rainfall

(ibid: 173). Their usefulness in this context is compromised by their being derived solely from Birdsell's main tribal series which encompass only the northwestern and western regions (covering barely 30% of the total Aboriginal geographical range). Also, each of his gradient analyses incorporates a restricted range of variables, and neither the biological significance nor the statistical validity of these composite indices is clear. Nonetheless the results of environmental analysis show a number of trends. For the non-metric morphological data, the variables attributed to polygenic inheritance (gradient B) show significant environmental correlations. The body and cranial metrical composite gradients (but not the facial composite) show correlations with temperature and moisture variables. The "composite" metrical composite gradient (body + cranial + facial composites) correlates mainly with the moisture, sunlight and maximum temperature variables. As Birdsell remarks, the "surprising thing with a combination of 17 metrical traits and 20 indices is that any differentiation whatsoever is evident" (ibid: 420). Not so surprising, and with one minor exception, when all these composite gradients are merged (i.e. the average of serological, dental, non-metric morphological and metric morphological composites), no environmental correlations are found.

*(ix) dental and serological data*

Results of environmental analyses for these data are included more for completeness, and indicate generally fewer and smaller correlations. For the dental data, there are some suggestions that size of dentition correlates with temperature and dryness (Figure 50). This is seen also with tooth displacement, which correlates with average maximum temperature (r = +.500). The number of molar cusps, on the other hand, tends to correlate negatively with temperature and positively with moisture (particularly rainfall) and, to a lesser extent, wind exposure. Palate breadth increases in cooler conditions, which may in part reflect concomitant changes in cranial shape associated with temperature. Results for serological data are difficult to interpret, especially given the higher incidence of correlations than might be expected. For the ABO system, the $A_1$ allele is more common in central and southern Australia while the B allele is restricted to Cape York and the Gulf of Carpentaria. This pattern may contribute to the negative temperature correlations for the A allele and the positive moisture correlations for the B allele. For the MN groups, the N gene is commonest in the western and southern desert areas, and also in the northeast Queensland rainforest area, and it shows modest negative temperature correlations. For the Rhesus genes, the geographical distributions are complex and Birdsell remarks that the $R^2$ patterns "underline the general proposition that blood group gene frequencies are in many cases no indicators of biological relationship" (ibid: 55); neither would they appear to be of much value as indicators of environmental associations.

**Factor analyses**

Factor analyses are included to assess the relative importance and consistency of trends on the environmental variables in relation to the major categories of morphological variation. Such analyses can assist in identifying underlying patterns or components, and their relationships may reveal consistent effects of certain combinations of environmental parameters on particular constellations of morphological attributes.

For environmental variables, only the seven indices from the Bureau of Meteorology are included. The remaining two, wind chill (Steadman formula) and Apparent Temperature, represent compound variables derived largely from the others, and would compromise interpretation of the results if not excluded.

An unrotated Principal Components Analysis (PCA) indicates that two components are sufficient, as shown in the scree plot (Figure 51). In the factor analysis, these two components together account for approximately 85% of total variance on the seven environmental variables (Table 18). In

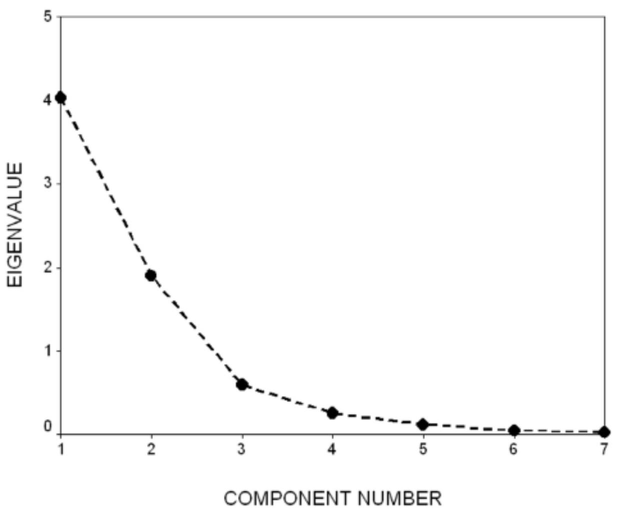



Figure 51 Environmental PCA – scree plot

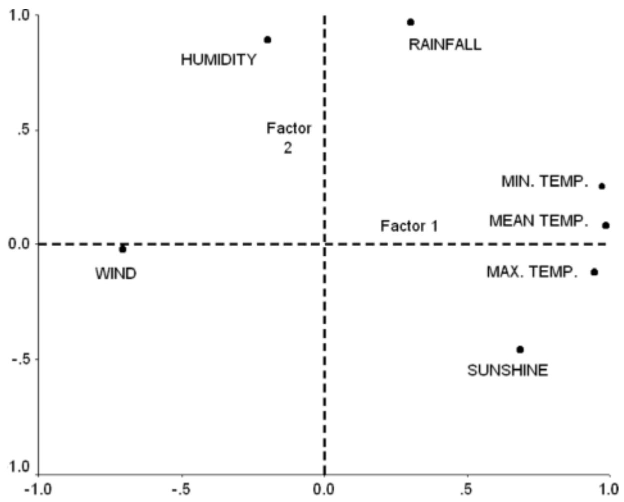



Figure 52 Environmental factors – loading plot

**Total Variance Explained**

| Factor | Initial Eigenvalues Total | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 4.036 | 57.656 | 57.656 |
| 2 | 1.903 | 27.182 | 84.838 |
| 3 | .597 | 8.528 | 93.365 |
| 4 | .257 | 3.678 | 97.044 |
| 5 | .126 | 1.796 | 98.839 |
| 6 | 5.395E-02 | .771 | 99.610 |
| 7 | 2.729E-02 | .390 | 100.000 |

Extraction Method: Maximum Likelihood.

**Total Variance Explained**

| Factor | Extraction Sums of Squared Loadings Total | % of Variance | Cumulative % | Rotation Total |
|---|---|---|---|---|
| 1 | 3.808 | 54.398 | 54.398 | 3.834 |
| 2 | 1.833 | 26.182 | 80.579 | 1.991 |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |

Extraction Method: Maximum Likelihood.
a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 18 Environmental factor analysis: total variance explained

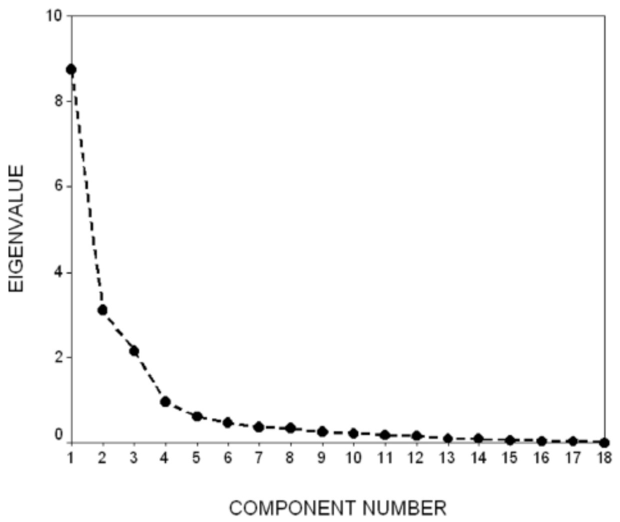



Figure 53 Morphology PCA – scree plot

**Factor Matrix[a]**

| | Factor 1 | Factor 2 |
|---|---|---|
| tmean | .990 | |
| tmax | .965 | |
| tmin | .941 | |
| sun | .713 | -.434 |
| wind | -.598 | |
| rain | | .907 |
| humid | -.352 | .863 |

Extraction Method: Maximum Likelihood.
a. 2 factors extracted. 5 iterations required.

Table 19 Environmental factor analysis: pattern matrix

the Pattern Matrix (Table 19), the first component has positive loadings on the three temperature variables, along with sunshine, and a negative loading for wind speed. Factor 1 is readily interpretable as an inverse wind chill factor. Geographically, it may correspond to more northern and more inland locations. Factor 2 has loadings on the two moisture variables, and a negative sunshine loading, with the latter suggesting cloud cover and / or higher latitude. Geographically, Factor 2 corresponds to southern and southeastern areas, and coastal locations. The loading plot for the two environmental factors is shown in Figure 52. Factor 1 is highly bipolar, and is labelled “N INLAND” in the following correlation analyses between environmental and morphological factors. Factor 2, also bipolar, is labelled as “SE COAST”.

For the morphological factor analysis, 18 variables are selected, covering a range of attributes and including those of interest in terms of thermal adaptations. Indices combining two or more variables are excluded. An unrotated PCA suggests three factors are sufficient (Figure 53) and, in the factor analysis these account for approximately 67% of total variance.

The loadings on Factor 1 include all of the limb segment lengths, along with stature, size of dentition, dark skin colour, and nasal width (Table 20). The lower limb segments contribute more than those of the upper limbs, and the distal segments contribute more than proximal segments for both upper and lower limbs. Factor 2 loadings include body hair and beards, lighter skin, head length, less curled head hair, and a higher incidence of tawny or

**Pattern Matrix[a]**

| | Factor | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Tibia | 1.005 | -.129 | |
| Femur | .929 | | |
| Radius | .907 | | |
| Humerus | .863 | | |
| Stature | .846 | | |
| Dental size | .728 | .365 | -.215 |
| Skin colour | .698 | -.541 | -.192 |
| Bizygoma | .556 | .213 | |
| Nose width | .518 | | .114 |
| Beards | -.114 | .936 | -.149 |
| Body hair | -.101 | .765 | .130 |
| Curly hair | -.210 | -.464 | .163 |
| Head length | .189 | .450 | |
| Blonde hair | .131 | .414 | -.873 |
| Face height | | | .572 |
| Shoulders | .259 | .319 | .549 |
| Head width | | .237 | .458 |
| Weight | .319 | .361 | .383 |

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 20 Morphology factor analysis: pattern matrix

"blonde" head hair. Factor 3 loads negatively on the latter, and the positive loadings include facial height, shoulder width, and head width. Body weight, it may be noted, loads poorly and quite evenly on all three factors, although the heaviest loading occurs on Factor 3. In deference to Birdsell, but without any connotations as to causes of the morphological variation, these three factors are labelled as follows, along with the abbreviations used in the subsequent correlation analyses:

1. Carpentarian [CARPEN18],
2. Murrayian [MURRAY18], and
3. Tasmanoid [TASMAN18].

**Correlations**

| | | INLAND | COAST | CARPEN20 | MURRAY20 | TASMAN20 |
|---|---|---|---|---|---|---|
| INLAND | Pearson Correlation | 1 | .000 | .347** | -.112 | -.082 |
| | Sig. (2-tailed) | . | 1.000 | .000 | .186 | .332 |
| | N | 142 | 142 | 142 | 142 | 142 |
| COAST | Pearson Correlation | .000 | 1 | -.331** | -.548** | .087 |
| | Sig. (2-tailed) | 1.000 | . | .000 | .000 | .301 |
| | N | 142 | 142 | 142 | 142 | 142 |
| CARPEN20 | Pearson Correlation | .347** | -.331** | 1 | .234** | .234** |
| | Sig. (2-tailed) | .000 | .000 | . | .005 | .005 |
| | N | 142 | 142 | 142 | 142 | 142 |
| MURRAY20 | Pearson Correlation | -.112 | -.548** | .234** | 1 | .342** |
| | Sig. (2-tailed) | .186 | .000 | .005 | . | .000 |
| | N | 142 | 142 | 142 | 142 | 142 |
| TASMAN20 | Pearson Correlation | -.082 | .087 | .234** | .342** | 1 |
| | Sig. (2-tailed) | .332 | .301 | .005 | .000 | . |
| | N | 142 | 142 | 142 | 142 | 142 |

**. Correlation is significant at the 0.01 level (2-tailed).

Table 21 Correlations between the environmental and morphological factors

**Correlations**

| | | CARPEN18 | MURRAY18 | TASMAN18 |
|---|---|---|---|---|
| CARPEN18 | Pearson Correlation | 1 | .234** | .234** |
| | Sig. (2-tailed) | . | .005 | .005 |
| | N | 142 | 142 | 142 |
| MURRAY18 | Pearson Correlation | .234** | 1 | .342** |
| | Sig. (2-tailed) | .005 | . | .000 |
| | N | 142 | 142 | 142 |
| TASMAN18 | Pearson Correlation | .234** | .342** | 1 |
| | Sig. (2-tailed) | .005 | .000 | . |
| | N | 142 | 142 | 142 |
| sun | Pearson Correlation | .351** | .136 | -.043 |
| | Sig. (2-tailed) | .000 | .107 | .608 |
| | N | 142 | 142 | 142 |
| tmax | Pearson Correlation | .324** | -.144 | -.063 |
| | Sig. (2-tailed) | .000 | .088 | .458 |
| | N | 142 | 142 | 142 |
| tmean | Pearson Correlation | .264** | -.257** | -.055 |
| | Sig. (2-tailed) | .001 | .002 | .519 |
| | N | 142 | 142 | 142 |
| tmin | Pearson Correlation | .146 | -.361** | -.116 |
| | Sig. (2-tailed) | .084 | .000 | .171 |
| | N | 142 | 142 | 142 |
| humid | Pearson Correlation | -.408** | -.309** | .156 |
| | Sig. (2-tailed) | .000 | .000 | .064 |
| | N | 142 | 142 | 142 |
| rain | Pearson Correlation | -.382** | -.553** | .093 |
| | Sig. (2-tailed) | .000 | .000 | .268 |
| | N | 142 | 142 | 142 |
| wind | Pearson Correlation | -.276** | .071 | -.003 |
| | Sig. (2-tailed) | .001 | .400 | .972 |
| | N | 142 | 142 | 142 |

Table 22 Correlations: 2 morphological factors and 7 environmental variables

Birdsell's data base, it may be mentioned, includes little data on Tasmanian Aborigines, underlying the arbitrary nature of these labels. The first factor, however, does correspond somewhat to his description of the "Carpentrains", while his "Murrayians" may be represented by a combination of factors 2 and 3. Linear regression analyses between the three morphology and two environmental factors result in the correlations shown in Table 21.

The first or "Carpentarian" morphology factor, comprising long limb segments, darker skin, larger teeth, and a wider nose, correlates with the first environmental factor, the inverse "wind chill" factor, corresponding to hotter, less humid, and less windy conditions. The second morphology factor, with greater body hair and lighter skin, correlates negatively with the second environmental factor, which is primarily a moisture factor. The third morphology variable, with broader shoulders and a larger face, fails to correlate with either of the environmental factors.

Overall, the factor analyses suggest significant environmental patterning of the first two morphological components, and the patterning is consistent with thermal considerations. In particular, the factors with limb length and body hair loadings correlate predictably with higher temperatures and lower moisture respectively. The importance of wind chill as a major thermal

factor is also evident. Further detail on the environmental relationships can be explored with linear regression of the morphology factors on the seven environmental variables (Table 22). On the temperature variables, the "Carpentarian" factor correlates most with higher maximum temperatures, while the "Murrayian" factor correlates (negatively) with minimum temperature, *i.e.* body hair increases as minimum temperatures decline.

**Osteological analyses**

Data for these analyses comprise the limited post-cranial data that exist for the Tasmanian Aborigines (Table 23), together with data for mainland Australian Aborigines derived from various sources. The analyses also incorporate data on other human groups, mainly those used in the Trinkaus (1981) study of Neanderthal limb proportions and cold adaptations.

Osteological indices of interest from a thermal perspective include the limb segment indices – the tibial-femoral (crural) and the radial-humeral (brachial) indices – and the claviculo-humeral index. The former relate to Allen's Rule, while the latter relates to body build (Bergmann's Rule) as well as limb proportions. Clavicular length provides an indication of the broadness or stockiness of body build, while humeral length relates to linearity of build as well as limb length. Clavicular length should be inversely related to humeral length and, since the latter forms the denominator, the claviculo-humeral index should represent an especially sensitive morphological marker of thermal adaptation.

Claviculo-humeral data for Australian Aborigines are from the Murray Black collection examined by Ray (1959), which derives from southeastern Australia. Tasmanian data, however, are limited to the measurements taken by Turner (1910) on a single individual. Despite this limitation, it has been included here as it represents the only osteological measure of body shape for which any Tasmanian Aboriginal data exist. When data for other human groups are included, together with "upper palaeolithic" modern humans and Neanderthals, a significant negative correlation is found between this index and mean annual temperature (Figure 54). The Australian Aboriginal sample (left and right-sided) has a low index, reflecting a more linear body shape. While the Tasmanian data are excluded from the linear regression analysis as they derive from a single individual (the other samples comprising group means), it can be noted that the index for this individual is markedly higher than the Australian averages, *i.e.* it corresponds to a more stocky build.

| | Femora (F) | Tibiae (T) | T/F | Humeri (H) | Radii (R) | R/H | Clavicles (C) | C/H |
|---|---|---|---|---|---|---|---|---|
| Barnard Davis 1874 (Roth 1899: 219) — remains of 4 individuals in UK institutions: | | | | | | | | |
| | 463 | 383 | 82.72 | 312 | 251 | 80.45 | | |
| | 434 | 380 | 87.56 | 302 | 246 | 81.46 | | |
| | 458 | 395 | 86.25 | 312 | 265 | 84.94 | | |
| | 388 | 309 | 79.64 | 266 | 234 | 87.97 | | |
| | | | 84.04 | | | 83.71 | | |
| Turner 1910: 433 — remains of individual in Brussels Museum (male): | | | | | | | | |
| | 422 (L) | 349 (L) | 82.70 | 279 (L) | 228 (L) | 81.72 | 131 (L) | 46.95 (L) |
| | 424 (R) | 353 (R) | 83.26 | 289 (R) | 231 (R) | 79.93 | 132 (R) | 45.67 (R) |
| | | | 82.98 | | | 80.83 | | 46.31 |
| Wunderly 1938: 336 — remains recovered from Eaglehawk Neck (unsexed): | | | | | | | | |
| | 480 | 366 | | | | | | |
| | 470 | 393 | | --------"unsuitable for-------- | | | | |
| | 459 | 388 | | | | | | |
| | 436 | 355 | | --reliable measurements"-- | | | | |
| | 415 | | | | | | | |
| | 491 | | | | | | | |
| | 458.5 | 375.5 | 81.90 | | | | | |
| Abbie 1962: 56 — W L Crowther collection: | | | | | | | | |
| | 480 (L) | | | 303- | 230 | | | |
| | 482 (R) | 405 (R) | | 313.5 | | | | |
| | 436 (L) | | | 324 | | | | |
| | 438 (R) | 358 (R) | | 286 | | | | |
| | 420 (L) | | | 303 | | | | |
| | 425 (R) | 351 (R) | | | | | | |
| | 446.83 | 371.33 | 83.10 | 305.9 | 230 | 75.19 | | |
| Sim & Thorne 1990: 48 — King Is (late Pleistocene): | | | | | | | | |
| | 426 | 347 | 81.46 | | | | | |
| *n:* | *20* | *14* | | *11* | *7* | | *2* | |
| means: | 445.2 | 366.6 | | 299.0 | 240.7 | | 131.5 | |
| | INDICES (average) | | Tibial-femoral (crural) | | | Radial-humeral (brachial) | | claviculo-humeral |
| | | | 82.34 | | | 80.50 | | 46.31 |

[measurements in mm.]

Table 23 Tasmanian osteological data

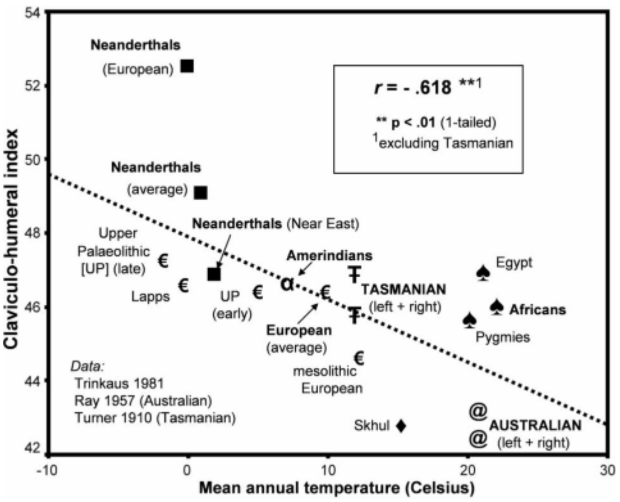



Figure 54 Claciculo-humeral index

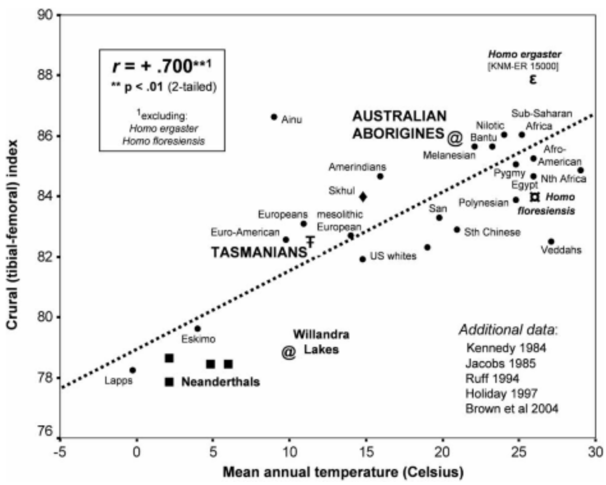



Figure 56 Crural index – human groups

For the crural index, most of the mainland Aboriginal data are taken from Donlon's 1990 PhD thesis, in which South Australian osteological remains were sourced to various regions within the state. Her data comprise separate means for males and females, and for left and right sides, which have been averaged here to be consonant with the other data. For Tasmania, only the Eaglehawk Neck (near Port Arthur) and the King Island data can be sourced to regions (and hence matched to more proximate meteorological stations). Nonetheless, even with the small sample sizes and limited geographical coverage, there emerges an overall trend on the crural index in relation to mean annual temperature (Figure 55). Both of the late Pleistocene samples, from King Island in Bass Strait and Willandra Lakes on the mainland, show reduced crural indices. For the linear regression analysis, data from individual remains such as Cowra and King Island are excluded, and all the Tasmanian data are excluded excepting the Tasmanian average from Table 24. The resulting correlation coefficient is nevertheless quite high ( $r$ = +.759).

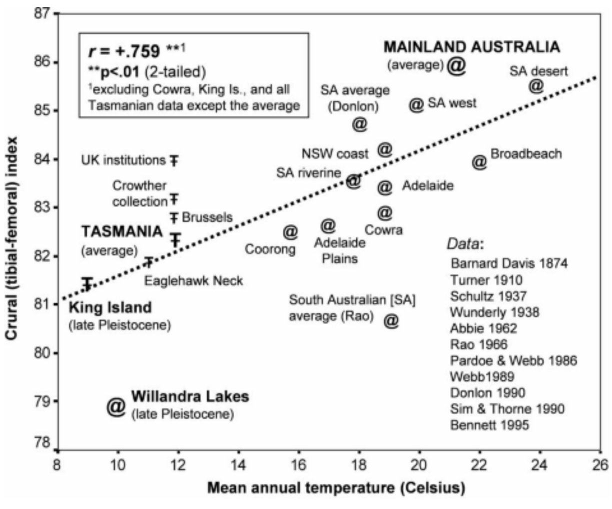



Figure 55 Crural (tibial-femoral) index – Aboriginal Australians

The Australian mainland and Tasmanian Aboriginal crural indices are shown in relation to other human groups (Figure 56), along with *Homo ergaster* from eastern Africa (KNM-ER 15000, dating to around 1.6 million years ago), and also *Homo floresiensis*. The latter occupies an unremarkable position, adjacent to Polynesians and in close proximity to Melanesians, and not far from the Veddahs of Sri Lanka. The Tasmanians are shifted towards the cold-adapted range in relation to the mainland Australian average. The position of the mainland late Pleistocene sample, Willandra Lakes, is noteworthy. It differs markedly from the mainland average, lying further towards the cold-adapted extreme than Tasmanians. Late Pleistocene Australians have been characterised as more "robust" than those from the Holocene, and it has been suggested that this could reflect an association with archaic hominins, namely *Homo erectus* in Java. If so, post-cranial data should reflect this association, and any pronounced shift from the modern Aboriginal average should be in the direction of *H. ergaster.* However, post-cranial evidence from Willandra Lakes suggests otherwise, *i.e.* cold-adapted morphological changes in the Pleistocene Aboriginal population.

Results for the brachial (radial-humeral) index are shown in Figure 57. Even allowing for the sample size being smaller than for the crural index, the Tasmanians in this analysis emerge as an outlier. More importantly, the Tasmanian index is shifted from the mainland average in the opposite direction to that expected on thermal grounds, *i.e.* the radius should become shorter relative to the humerus in colder conditions, leading to a lower index, whereas the Tasmanian index is higher. If this result is reliable, it represents an anomaly.

One possibility to be considered is that cultural adaptations, namely use of clothing, may affect the development of morphological adaptations. The European samples, with"upper palaeolithic" samples having more "tropical" brachial indices than mesolithic or modern samples, are also anomalous. These aspects are explored below.

## Discussion

The results of the Birdsell re-analysis show that considerable patterning of morphological variation exists within the Australian Aboriginal population. Most of the major regional trends documented by Birdsell (and other workers) are found to vary in concert with environmental conditions. Significant environmental correlations exist for the main measures and indices relating to body shape, limb lengths and proportions, and head size and shape. Thermal trends are prominent, but other environmental variables also show significant trends, particularly the moisture variables (humidity and rainfall). That these findings in part reflect morphological responses to environmental conditions is suggested both by the trends occurring in directions predictable from biological principles, and by a lower incidence of significant trends among those morphological variables that would not be expected to show such correlations.

Stature and linearity of body build correlate positively with temperature. This trend is clearly evident for the ponderal index, where low values indicate a relatively stocky build in cooler areas. Body weight however fails to show any correlation with temperature variables. Birdsell observes that this measure is quite unreliable, as all the data were collected among Aboriginal populations exposed for at least some decades and often several generations to a non-indigenous diet, and rapid weight gain was common. This may have had a disproportionate effect among those tribal populations with a lower initial mean body weight, reducing any pre-existing trends. As noted earlier, the data set is biassed towards northern and northwestern samples, which further compromises the results. Yet Birdsell, in referring to “a residue of differences relating to hypothetical waves of incoming populations”, suggests that his southern Murrayians were “moderately heavy for their height”, while Warner's data for the northern Arnhem Land groups suggest the latter were of “lesser weight” (Birdsell 1993: 307).

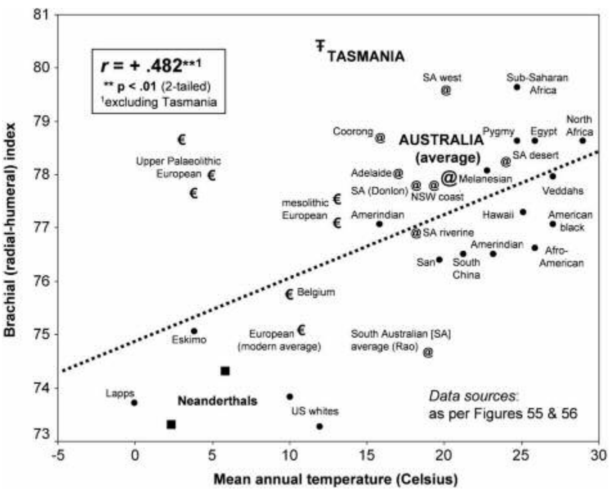



Figure 57 Brachial (radial-humeral) index

Sitting height, which in studies of other groups worldwide correlates negatively with temperature (Roberts 1978: 20), shows a positive relationship among Australian Aborigines. This is difficult to interpret, although it could reflect a predominant total stature effect among a population with an overall tropical linear morphology. A secular trend is another possibility, given that sitting height increased rapidly (by an average of 2.1cm) among three Western Desert tribes examined in 1939 and 1952 (Birdsell 1993: 424). Sitting height also correlates positively with sunlight and negatively with moisture, with the latter possibly reflecting the reduced cooling value of a greater surface area in more humid conditions. Relative sitting height nonetheless shows a small negative temperature correlation and a positive correlation with moisture, consistent with predicted thermal trends. Shoulder breadth increases with lower minimum temperatures, as does relative shoulder breadth, both suggesting a more stocky body shape in the cooler southern and southeastern areas.

Limb measures show strong and consistent environmental correlations, with temperature trends in accordance with Allen’s rule. These tend to be even more evident for the distal limb segments, again as predicted. That is, limbs become shorter with lower temperatures, and this applies particularly to the distal limb segments (radial and tibial lengths and indices). Correlations are highest for mean minimum temperatures (e.g. +.738 for tibial length and +.579 for the tibial-femoral index), suggesting that response to cold is the more salient effect. Negative temperature correlations for the intermembral index (upper limb length ÷ lower limb length) show how this effect is most marked for the longer (i.e. lower) limbs, and there are interacting thermal effects for moisture and wind as shown by the wind chill and mean apparent temperature correlations. The only exception to predicted thermal trends among the limb measures occurs with maximum calf girth, where no environmental correlations are found, which may reflect a nutritional (obesity) effect in the populations sampled. The calf-tibial index, a better measure of stocky proportions, shows the expected environmental correlations. Limb-body indices are less conventional measures and show lower and more varying thermal trends, although both distal limb segment ratios (radial-sitting height and tibial-sitting height) have positive correlations with some of the temperature variables, suggesting that these limb segments become proportionally longer in warmer environments.

The major cranial measures likewise show significant environmental correlations. The size and the shape of the cranium varies mainly with temperature, with the head becoming larger and rounder as temperatures decline. This follows the thermal trends documented among other human groups, where brachycephalisation correlates with colder and especially cold and dry conditions, where evaporative heat losses are greatest (Beals 1972). Cold adaptation may be more important for the cranium in circumstances where the body is protected by clothes but the head is left exposed (ibid: 90), as may be the case for Australian

Aborigines in the cooler areas. Facial and nasal measures tend to show more pronounced correlations with moisture variables, as does basal cranial breadth, which is greater in drier conditions (e.g. $r = -.704$ on the rainfall variable).

Besides temperature, the other key environmental variables identified in studies of morphological variation among other human populations include humidity, wind velocity, and solar radiation. Each tends to be correlated with temperature but can also have an independent association with certain morphological features. Nasal shape for instance correlates more strongly with humidity than with temperature (Thomson and Buxton 1923, Weiner 1954, Wolpoff 1968). Moisture in the form of humidity and rainfall also affects the relationship between temperature and body shape. The cooling advantage of a higher surface/volume ratio in hot environments depends largely on evaporation of perspiration from the skin surface. Evaporative cooling is compromised in conditions of high atmospheric moisture content, especially if coupled with reduced wind chill, as is the case in relatively closed (e.g. heavily forested) environments. This has been posited as an explanation for the reduced body size of the Pygmy and Negrito populations which reside in hot, humid rainforest habitats. In these circumstances, where keeping cool is the main priority, a large exposed skin surface is of little use for evaporative cooling, but a lower body mass means less metabolic heat production, so the net morphological result is reduced body size (Hiernaux et al 1975: 7-9, Cavalli-Sforza 1986: 394-402). In Australia, the small stature of the “Tasmanoid” or “Negrito” Aboriginal groups in the hot rainforest areas of north Queensland (Tindale and Birdsell 1941) may be more a consequence of these local thermal conditions, rather than any genetic contribution from hypothesised ancient Negrito immigrants into the area. Also, low levels of sunlight in forested habitats have been implicated, leading to reduced body mass in response to reduced vitamin D synthesis (O’Dea 1993). The advantages of a small body size in moving through dense vegetation has been mentioned in the Southeast Asian rainforest context (Bulbeck 1999: 16), while a distinctive lifestyle including dietary considerations might also play a role (ibid, Cosgrove 2003).

Morphological features other than body shape and limb proportions have also been interpreted as environmental adaptations. Craniofacial shape has been a focus of much debate as to climatic factors, mainly wind chill (e.g. Koertvelyessy 1972, Steegman 1972). Variation in scalp hair form has been subject to speculation as to whether more curled or tightly coiled hair has adaptive value, perhaps in either hot or very humid or wet environments (Coon *et al.* 1950: 63, Coon 1965: 175, Bulbeck 1999: 17). Skin pigmentation generally correlates with levels of sunlight, although other factors may be involved and the physiological processes and possible adaptive benefits are complex (Weiner 1971: 139-140, Harrison 1975, Bulbeck 1999: 19, Jablonski and Chaplin 2000). Clothing use, or lack thereof, is also a factor. The regular use of tailored garments that cover most of the skin surface (including the limbs) probably became established among some populations during the late Pleistocene in response to thermal rather than cultural requirements (Gilligan and Walker n.d.: 17-65). Such “complex” clothing would contribute to a lighter skin colour among humans in high latitudes, whose descendants and their sociocultural repertoires later spread into lower latitudes. For instance, the lighter skin colour of Senoi horticultural groups compared to their Semang hunter-gatherer neighbours in tropical Southeast Asia (Bulbeck 1996: 37) may in part reflect a greater use of garments (made from woven vegetable fibres or beaten bark cloth), for which archaeological evidence exists in the form of bark cloth beaters (Bulbeck 2003: 150). The advantage of dark skin as camouflage to evade predators in rainforests has also been cited (Turnbull 1986, Bulbeck 1999: 18). However this last factor is less relevant to the lighter skin of rainforest Aborigines in northern Australia (ibid) where, interestingly, beaten bark cloth was used in the form of “blankets”, perhaps more as protection from the high rainfall (Tindale and Birdsell 1941: 7). In any case, all of these factors need to be considered, including the post-glacial expansion into lower latitudes of peoples and cultures associated with the habitual use of clothing (for social if not thermal reasons). The end result is a complicated picture for the global distribution of human skin colour in the late Holocene (Jablonski and Chaplin 2003).

In the present study, skin colour (intensity of pigmentation) among Australian Aborigines is found to correlate more strongly with temperature and wind than with sunlight, and it also correlates negatively with moisture. Some of this variation may be related to clothing use for thermal reasons, both pre- and post-White settlement, resulting in lighter skin in cooler areas. Abbie for instance reported that the dark skin colour of mainland Aborigines who adopted European clothing tended to fade on “parts of the body habitually covered by clothing” (Abbie, 1969: 29). Another reason for the association between temperature and skin colour is that darker skin may be advantageous in hotter environments, as it results in a warmer skin surface which aids cooling through direct radiation (Harrison 1975: 189). Conversely, a lighter skin tone absorbs less heat, leading to a cooler skin surface that reduces net heat flux from the body core to the environment, which is thermally advantageous in cooler regions. The correlation with wind chill also suggests a thermal effect of skin pigmentation, as wind exaggerates the effect of temperature on heat transfer from the skin, both in terms of enhanced cooling in hot areas and exacerbated chilling in cooler environments. The latter may also be relevant to the negative correlation between skin pigmentation and moisture (cf. Abbie 1975: 116-125), as evaporative heat losses will be greater from a warmer (darker) skin surface. This problem will be worse in windy locales with high rainfall such as Tasmania, where the Aboriginal population is often described as having a lighter or coppery skin tone.

In terms of the relationship between latitude and vitamin D synthesis, the daily influx of UV radiation is inadequate when the sun fails to reach 20˚ above the horizon for more than a month or two, and the critical latitude where this occurs in winter is around 40˚ north and south of the equator. A less pigmented skin surface that facilitates penetration of UV light will become especially advantageous beyond this latitude, which corresponds to that of Tasmania. In such regions, the problem can be minimised by a diet favouring foods rich in vitamin D, such as fish and marine mammals (Coon 1965: 232, Jablonski and Chaplin 2003: 77).

Body hair among Australian Aborigines correlates negatively with temperature in this study (see also Kirk 1983: 90, cf. Abbie and Muecke 1971). The negative correlation with moisture may result from the reduced thermal value of hair in reducing heat loss in moist conditions, especially where rainfall is high. The variables relating to the form of head hair provide some interesting trends, suggesting some relationship (whether adaptive or a direct environmental influence) between more curled scalp hair and moister conditions. The high correlations for early onset of grey hair and baldness may reflect direct environmental effects.

Among the other minor morphological variables, environmental correlations tend to be either low or else rather enigmatic. In the latter category can be included the many variations in ear form. Why a less vertical ear axis or more protruding ears, for instance, should correlate with warm or moist environments, is unclear. Ear lobe attachment, on the other hand, may have adaptive value in colder, wetter environments. All three prognathism measures (total, facial and alveolar) correlate negatively with apparent temperature, and alveolar prognathism in particular is less pronounced in colder, windier and drier environments. Brow ridges tend to be smaller in cooler regions, though the relationship with temperature is not strong, and they tend also to be more continuous in areas of high rainfall.

For the osteological data, the claviculo-humeral index shows the predicted thermal trend. High values on this index indicate a more stocky body build, and it constitutes the only available such measure for the Tasmanian Aborigines (although measures of skeletal robusticity such as femoral shaft circumference might provide an indirect measure). Using the data in Trinkaus (1981) on late Pleistocene hominids and modern human groups for comparison, mean measures for the Australian Aborigines show a tropical or linear pattern, more so than any other human group, Africans included. The data for Tasmanian Aborigines, it must be reiterated, derive from clavicular measurements on the remains of a single Tasmanian individual, and data for the mainland Aboriginal sample show a wide range of variation (Ray 1959: 220). Additional clavicular data for Tasmanians would be of value in this regard, but it appears none are available; when Abbie gained brief access to the Crowther collection, for example, he gave priority to measuring crania, and post-cranial measurements are limited to the major limb bones and some vertebral elements (Abbie 1962: 56). The Tasmanian claviculo-humeral index given here must therefore be considered to be of little if any value for comparative or statistical purposes, although, if it were representative, it would be consistent with a more stocky body shape in this southern Aboriginal population.

The Tasmanian crural index data derive from a reasonable sample size, and indicate a marked divergence from the mainland Australian samples in the direction predicted by thermal principles. As such, the crural index provides the best post-cranial osteological evidence for greater morphological cold adaptation in the Tasmanian Aboriginal population.

Results for the brachial index are anomalous in that they run counter to predicted thermal trends. The sample size for the Tasmanians is admittedly small, barely half that of the crural index sample, comprising only 11 humeri and 7 radii (Table 23). If valid, however, the "tropical" brachial index may reflect the use of clothing, as mentioned earlier. Specifically, the type of garment utilised by Tasmanian Aborigines during the late Pleistocene, while likely to be more substantial than that documented in the late Holocene, probably consisted only of capes or cloaks draped from the shoulders. These, rather than the more sophisticated or "complex" garments tailored and fitted to cover both upper and lower limbs that became mandatory for modern humans in northern middle latitudes during the late Pleistocene, would provide thermal protection for the upper limbs (and the shoulders), but not for the lower limbs, at least not to the same extent. The upper limb, including the distal segment, is thus comparatively insulated from thermal environmental selection pressure, and can retain more "tropical" proportions. Lower limbs, in contrast, are relatively exposed to the elements even with the use of such loose cloaks, and will be more subject to selection. Another consideration is that the lower limbs are more vulnerable to cooling due to body motion, in walking for example. In other words, greater motion results in greater local air movement, or wind chill, for the lower limbs. This "bellows" effect is a problem even when fitted garments such as trousers or skirts are worn.

Another anomaly with the brachial index which may reflect the role of clothing is evident with the European samples (for fully modern humans). The late Pleistocene average preserves almost tropical proportions, which would have been possible among these immigrants from lower latitudes by virtue of their possessing "complex" clothing. There follows a paradoxical reduction in the brachial index among Europeans in the "mesolithic" and more recent samples, despite warmer environmental conditions after the last ice age. Again, an interaction with clothing may be responsible, with reduced protection leading to greater exposure, compounded by a transition to more widespread use of woven textile garments which are more permeable (to air and moisture) than furs and hides - textiles are thus

more comfortable in a post-glacial environment, but generally provide less insulation.

The Ainu of northern Japan also represent an anomaly, this time on the crural index (no brachial index data being given in the source, Kennedy 1984). Their proto-Australoid affinities, especially in dentition, ,may suggest a more southerly origin, and the duration of their presence in the region is unclear – there may be an association with the Jomon culture dating to the terminal Pleistocene / early Holocene. Culturally, the Ainu prior to Western influence often wore heavy clothing, mainly draped, but sometimes supplemented with fitted trousers (Fitzhugh and Dubreuil 1999), which may have allowed them to retain comparatively long distal lower limb segments.

Turning briefly to Birdsell's interpretation of his morphometric data, it is evident from the above results that most of the morphological attributes of his three ancestral groups – Carpentarians, Murrayians and Negritos (Birdsell 1949, 1967, Tindale and Birdsell 1941) – have environmental associations. Birdsell himself calculated correlations for tribal densities and mean annual rainfall, and concluded from the high r value of 0.81 (accounting for 65% of variance) that "a very close causal relationship exists between rainfall and the size of tribal territory"; he concluded that tribal densities are "rigorously subject to environmental determinism" (Birdsell 1953: 201). His data on morphological variation lend themselves to a similar test for environmental associations. Birdsell's interpretation of his data is not so much refuted as rendered more redundant by these results, adding to the general consensus that his trihybrid model is now "irrelevant" (Mulvaney and Kamminga 1999: 155). His data, however, are not.

In this study, environment accounts for a significant proportion of the variation on the major measures of morphological variation. The question arises as to what accounts for the rest of the variation. Given the known variability in measures such as limb ratios within even small samples, random variation would contribute a certain amount, although Birdsell provides no data on intratribal variation. Factors identified in studies of Aboriginal osteological remains include variation in sample sizes and selection procedures, measurement methods and standards, sexual dimorphism, age effects, asymmetry between left and right and, last but not least, the influence of behavioural variation (e.g. dietary and activity patterns) on morphological development (Bennett 1995: 3-37). In the latter category are the varying effects of White contact, including tribal dislocation and disruption of indigenous lifestyles since the beginning of European settlement in Australia.

## Conclusions

These analyses indicate that a sizeable proportion of morphological variation within the Australian Aboriginal population is associated with climate. Significant correlations emerge on measures and indices relating to body shape, head size and shape, limb lengths, and limb proportions. In general, the correlations occur on the environmental variables and in directions predictable from biological principles of long-term human adjustment to environmental conditions.

Post-cranial and other non-cranial data reveal the existence of considerable variability among Australian Aborigines, more so perhaps than is apparent in cranial data alone. The variation manifests a clinal pattern that follows environmental gradients across the continent and into Tasmania. The results are consistent with a single ancestral population modified by exposure to prevailing conditions. The existence of these trends in concert with climatic variation in the region reflects also past exposure to the altered environmental conditions of the late Pleistocene, including colder thermal regimes. For this reason, the findings have implications for palaeoanthropology as well as physical anthropology, for the interpretation of Aboriginal morphological variation past and present.

Reliable morphometric data for the Tasmanian Aborigines are virtually non-existent. The existence of thermal morphological patterning on the mainland may nonetheless suggest that such a trend would extend to Tasmania. To address this deficiency, the Birdsell re-analysis has been augmented here by osteological analyses, which incorporate Tasmanian data. While interpretation of the latter is limited by modest sample sizes, some (though not all) of the findings point to the likely presence of greater morphological cold adaptation among Tasmanian Aborigines in comparison to the mainland Australian Aboriginal population. The development of any such adaptations during the late Pleistocene, and their persistence (perhaps attenuated) through the Holocene, will necessarily interact with minimal clothing requirements as determined by thermal physiological considerations, and so be of some relevance to the ethnographic evidence for a Tasmanian clothing paradox.

Another aspectis the extent of thermal selection for cold adaptations (both morphological and cultural) during the late Pleistocene, which can be examined using palaeoenvironmental evidence for Tasmania in relation to human physiological thresholds. This, in conjunction with archaeological evidence for human behavioural responses to the altered thermal conditions, is the subject of Study 3.

# STUDY 3: PREHISTORY

## Chapter 9 Introduction and Method

### Introduction

In this study, past thermal conditions in Tasmania are reconstructed from palaeoenvironmental data. Wind chill is the most relevant aspect in terms of cold tolerance, particularly in relation to the thresholds or limits beyond which morphological adaptations and behavioural responses become critical for human health and survival.

With regard to behavioural responses, archaeological evidence for the development of clothing is of most interest in relation to the Tasmanian clothing paradox. While any garments themselves will have perished, inferences as to the likely existence and the basic form of clothing can be made, based on two strategies. First, the reconstructed thermal environments can be assessed in relation to the minimum physiological requirements. Results should allow deductions to be made as to whether clothing was essential. Second, the archaeological record can be examined for evidence, not of clothing *per se*, but for proxy indicators of thermal responses. One such indicator is the use of natural shelter for protection from wind chill. Other indicators, beyond the scope of this study, are reviewed later in the main Discussion section. They include patterns of resource exploitation that may relate to increased caloric needs and the acquisition of raw materials for clothing, and the development of technologies required to manufacture clothing.

The use of shelter in prehistoric Tasmania in relation to wind chill is not only a proxy indicator of human behavioural response to thermal conditions. It also bears directly on one of the challenges posed by the Tasmanian archaeological record – the unexpected presence of humans in the southwest highlands during the late Pleistocene. Environmental reconstruction is utilised here to estimate wind chill levels, and also to consider other environmental factors that will affect the need for, and the availability of, shelter. This thermal analysis may provide a useful perspective from which to address the archaeological challenge.

#### The Southwest Surprise

Before archaeological evidence to the contrary began to come to light in 1975, it was widely held that environmental conditions during the late Pleistocene precluded human habitation of southwest Tasmania, particularly during the Last Glacial Maximum (LGM). Jones for instance surmised that "most of Tasmania was inhospitable and probably uninhabited... and any human occupation would have been tightly coastal" (Jones 1968: 200, see also Macphail 1975: 299, Mulvaney 1975: 170, Bowdler 1977: 218-219, Jones 1977: 336-338, Lourandos 1977: 223).

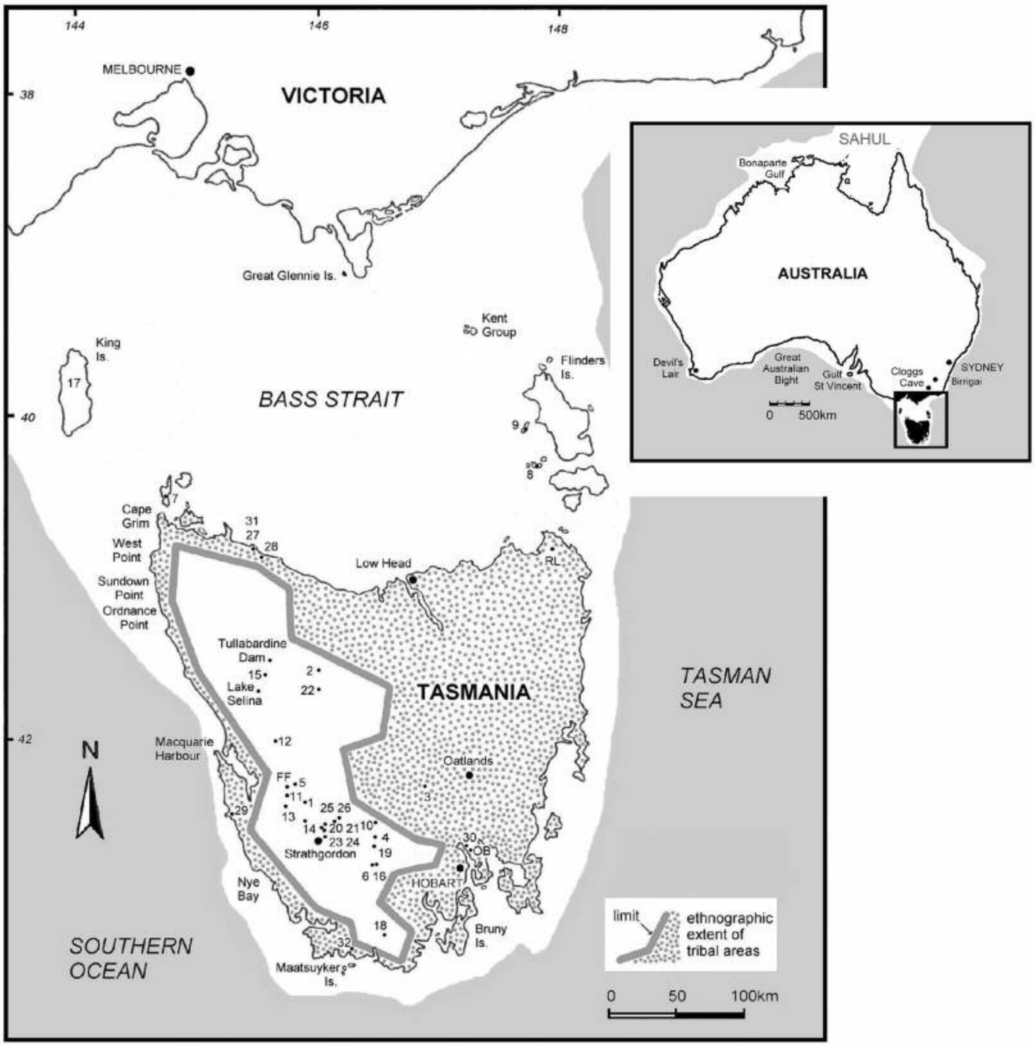
Ethnographic and historical accounts of the Tasmanian Aborigines added credence to these expectations. The majority of the fifty or so bands were coastal, with perhaps ten based in the midlands, and their seasonal movements favoured the milder coastal zones in winter months (Meston 1949: 147-148, Jones 1974: 325-327, Ryan 1996: 14-44). None remained inland all year, nor did any frequent the rugged, heavily-forested ranges of the southwest (Plomley 1966: 128).

White explorers first entered the southwest in the 1830's and 1840's, when evidence of an Aboriginal presence was occasionally reported (Burn 1842: 19, Binks 1980: 152, Kiernan 1982: 77-80). For instance in December 1840, near the Franklin River, Calder came across two huts constructed of tree bark that were "sufficiently compact to afford good shelter" (Calder 1849: 419). By that time, however, Aboriginal society on the island had already been severely dislocated (Plomley 1987: 1-169).

In contrast to the ethnographic and archaeological records, which show minimal human presence in the Tasmanian southwest during the Holocene, the Pleistocene archaeological record tells a different story (Figure 58).

Numerous cave and rockshelter sites have been identified in the southwest (Jones 1995, Allen and Cosgrove 1996a, Cosgrove 1999). Two Pleistocene sites (Parmerpar Meethaner and ORS7) lie just outside the southwest zone, to the north and east respectively, and there are also Pleistocene cave sites on two Bass Strait islands (Bowdler 1984, Brown 1993). There is one open site in the southwest dating to the Pleistocene, Flying Fox (Jones *et al.* 1983: 66-67). Conversely, with the exception of the Bass Strait sites, along with the two sites near the southwest and one open site (Old Beach) near Hobart, no Pleistocene sites are documented outside of the southwest (Sigleo and Colhoun 1975: 302, Cosgrove 1985: 32, Freslov 1993, Jones 1995: 441). Moreover, signs of any human presence in the area during the Holocene occur only at a few sites near its northern fringes (Cosgrove and Allen 2001: 422), and at one (Parmerpar Meethaner) there is a "dramatic drop" in the lithic discard rate (Cosgrove 1995a: 91) after 10,000 years ago (10 ka). This human presence in the Tasmanian southwest during the LGM has been a major "surprise" for Australian archaeology (Beaton 2000: 184), underlined by mounting evidence that it occurred in winter (Cosgrove and Pike-Tay 2004: 329) - "the most stressful period of the year in terms of lower temperatures, increased bodily needs and limited food resources" (Cosgrove 1997: 53).

Natural shelter in the southwest has been cited as an advantage for humans during the LGM (e.g. Freslov 1993: 237, Thomas 1993: 8), but the varying patterns of site utilisation suggest "no necessary correlation between the intensity of glacial conditions and cave use" (Cosgrove *et al.* 1990: 66). Instead of looking at how thermal conditions may have affected humans directly, most research has focused on how glacial climates would have altered the animal food resource options available to humans. Aridity




KEY:

*Pleistocene*

1 Warreen
2 Parmerpar Meethaner
3 ORS 7
4 Numamira
5 Pallawa Trounter
6 Bone Cave
7 Cave Bay Cave
8 Beeton Shelter
9 Mannalargenna
10 Tiata Mara Kominya
11 Kutikina
12 Maneena Langatick Tattana Emita
13 Deena-Reena
14 Piniga Nairana
15 Mackintosh
16 Stone Cave
17 Cliff Cave
18 Wargata Mina
19 Nanwoon
20 Ballawinne
21 Artefact Creek West
22 Warragarra
23 Artefact Creek North
24 Artefact Creek Top
25 Condominium Cliff CC1
26 FNR rockshelter
FF Flying Fox (open site)
OB Old Beach (open site)

*Holocene*

27 Rocky Cape South
28 Sister's Creek
29 Point Hibbs
30 Shag Bay
31 Rocky Cape North
32 Louisa River Cave 1
RL Rushy Lagoon (open site)

Figure 58 Tasmanian late Quaternary sites

is implicated as one factor, resulting in less predictable faunal resources in the east. In the southwest, on the other hand, small marsupials such as Bennett's wallaby represented a high-value resource that could be reliably exploited by human hunters (Cosgrove 1995a, 1995b: 100-107, 1999). The present study adds another dimension to the debate as to how environmental changes impacted on human behavioural options during the late Pleistocene. It draws attention to local thermal conditions and how these may relate to certain large-scale trends in the archaeological record, with protection from wind chill and access to shelter being especially pertinent from a thermal perspective.

An awareness of thresholds and limits in thermal physiology, and of predictable human behavioural responses to conditions that approach or exceed those limits, has yet to permeate an archaeological tradition that emphasises the impact of environmental change on comestible resources. Moreover, thermal factors can seem too "simple", and it might appear that "judgments about temperature tolerances should be made with caution, if at all" (Bowdler 1984: 130). The presence of sites close to Pleistocene ice sheets indeed seems to show that humans were unperturbed by the "extreme climatic variations" (Cosgrove 1989: 243), and it is true that exploitation of the region during the less clement seasons certainly "challenges the idea that these areas were too cold for hunter/gatherers, particularly during the winters of the LGM" (Pike-Tay and Cosgrove 2002: 138).

**Ethnographic evidence**

Tasmanian Aborigines were hardly indifferent to cold, even in the late Holocene. While their habitual nudity at the time of early European contact attests to a high degree of cold tolerance, this was supplemented with behavioural adaptations. Use of the three fundamental human adaptations to cold – fire, shelter and clothing – was comparatively minimal and casual, but was not totally absent. The ethnographic record documents the behavioural and technological responses of Tasmanian Aborigines to life in a cool temperate climate, where strong winds can result in a marked wind chill effect.

With respect to clothing, or an habitual absence thereof, the Tasmanian Aborigines were commonly described as being devoid of any coverings. Wallaby skins were sometimes worn loosely over their shoulders, more so among the women and in winter months (Péron 1809: 196, Flinders 1814 I: clv, Roth 1899: 128-131, Kelly 1921: 175, Lord 1928: 80, Le Dez 1992: 34). Women often used the garments to hold their infants (Cook 1785: 96-103, LaBillardière 1800: 127, 296), or else as a "sort of bag, in which they place what they are given or what they gather when out walking" (Baudin 1974: 344). Their predecessors would presumably have used more clothing in the late Pleistocene (Jones 1990: 284, Cosgrove 1997: 54), and their subsequent ability to manage with less protection during the Holocene has been cited as one example of their "maladaptive" cultural decline (Henrich 2004: 208-209).

With regards to fire, making and keeping fire presented certain challenges in a moist and often windy environment. While the Tasmanian Aborigines were never observed making fire, ethnographic accounts suggest they used flint-like stones and tinder to light fires by the percussion technique (Völger 1973: 60-61). This would have proven more difficult at times when fire was most likely to be extinguished, namely in the wettest and windiest conditions. As a precaution, and for convenience, they frequently carried lighted sticks, and if fire was lost they could also obtain it from neighbouring bands or from bushfires caused by lightning strikes (LaBillardière 1800: 310-312, Cosgrove 1984: 51-52, Plomley 1983: 201-202). Fire was utilised for many purposes, including personal warmth and cooking, and to drive out game from forests, and as a form of signaling between bands (Breen 1992: 43). The knowledge and skills of fire-making may have been possessed by only some members of a tribe, or have been guarded as a secret, and the fire-plough method may also have been used (Gott 2002: 653-654). Claims that the Tasmanian Aborigines could not make fire (e.g. Tylor 1878: 235-236), based solely on a lack of direct observation by Europeans, are no longer considered tenable (Breen 2003: 143).

In terms of shelter, three forms of fabricated protection are documented: wind-breaks, hollowed tree-trunks, and temporary huts (Furneaux, in Cook 1777: 113-114, Rickman 1781: 44, Mortimer 1791: 17-18, LaBillardière 1800: 99, 101, 102, Bass and Flinders, in Collins 1802: 121-122, Ross 1831: 114, Crozet, in Roth 1891: 21, Bligh, in Lord 1923: 11, Baudin 1974: 303, 345, D'Entrecasteaux 2001: 31). Bligh was of the view that hollowed tree trunks were used only as a "fire place" for cooking (Bligh, in Mackaness 1943: 11). Tasmanian Aborigines also used natural rock shelters and caves where these were available. On Bruny Island, LaBillardière found signs that they sometimes prepared meals in the caves (LaBillardière 1800: 323). On the northwest coast in 1830, Robinson visited two caves that had been "frequented by natives"; the one near Cape Grim "had often served as a shelter for the natives during a storm" (Plomley 1966: 175-183). Robinson recorded another, rather unusual form of shelter at Sundown Point on the west coast in September 1833, consisting of semicircular depressions dug out of the leeward side of a hill (ibid: 790). The use of huts was largely seasonal, and those built on the more exposed western coast were generally of more substantial construction (Jorgensen 1829: 48-49, Milligan, in Nixon 1857: 25, Robinson, in Plomley 1966: 229, Bowdler and Ryan 1987: 323, Jorgensen 1991: 58). Some were almost semi-subterranean, built within large holes dug into the ground for added protection from the wind (Plomley 1966: 858). Péron, on the 1802 Baudin expedition, noted that protection from the southwesterly winds appeared the paramount issue:

> *We presently discovered a hut belonging to the natives; it was simply a shelter of bark disposed in a half circle, and supported against some dry branch-*

*es: so slight a shelter could have no other object than that of protecting the inhabitant from the action of the cold wind. I observed that its convexity was effectively opposed to the S.W., which on these shores is the most constant, the most impetuous, and the most severe*

(Péron 1809: 176)

## Human cold tolerance

The main principles and findings in thermal physiology that relate to thresholds and limits of human cold tolerance have been reviewed earlier, in the main Introduction. To briefly recapitulate, the optimal or "ideal" air temperature for modern-day humans is around 25°C. Shivering begins on brief exposure to temperatures around 13°C, and temperatures below 0°C are dangerous for exposed humans, in terms of the risk of frostbite and hypothermia. Survival times for exposed humans in these conditions are measured in hours. Acclimatisation, along with other physiological adjustments among peoples habituated to some degree of cold exposure, leads to somewhat lower critical thresholds, but only by a few degrees Celsius. Australian Aborigines manifest some unusual physiological responses that allowed them to tolerate a greater degree of body cooling than other modern human groups. Their cold tolerance prior to the adoption of European-style clothing was sufficient to enable them to sleep naked in the central Australian desert, where nocturnal air temperatures can fall to around -5° C, although they made use of fires, body heat from their companions (and their dogs), and windbreaks. The wind chill temperature is the single most critical parameter affecting human cold tolerance, and protection from moisture (especially rain) is also important. Based on the various experimental findings, and taking into account the ethnographic evidence, the effective cold tolerance limit for Australian Aborigines during the late Pleistocene equates to a wind chill level in the vicinity of -5°C.

## Wind chill

Wind chill data are not calculated by the Australian Bureau of Meteorology. In part, this policy reflects the view that the Holocene environment in Australia is comparatively warm by global standards (cf. Steadman 1994: 11), and also the common perception that wind chill is mainly a northern hemisphere problem. This is belied by an incident that occurred in January 2004, on the southeastern coastline of Australia, when some 45 lifesavers required medical attention for hypothermia after their surfboat marathon was caught unexpectedly by a "cold, southerly wind change" (http://www.abc.net.au/news/australia/nsw/bega). This happened among healthy young adults, at latitude 36°43'S, at sea level, in mid-summer.

Wind chill data in Australia are limited mainly to alpine regions in the southeast, particularly the winter ski fields in the Snowy Mountains (e.g. http://ski.com.au/weather). Accurate wind-chill averages require simultaneous measures of temperature and wind speeds, and these data are not obtainable for Tasmania. Available data comprise average monthly air temperatures and wind velocities, which can give a proxy measure of average wind chill. While this is not ideal, the error associated with estimates derived from weekly averages is only a few percent, compared with true averages calculated using synchronous temperature and wind velocity data (Court 1948). Monthly averages of temperature and wind speed have been used in meteorological studies to estimate average wind chill, where more precise data are not available (Steadman, pers. comm.), although this exaggerates the errors that arise through masking the true range of variation and ignoring the problem of co-variance between wind and temperature (Dixon and Prior 1987: 10). Nonetheless, this average should be acceptable for the present purposes of evaluating large-scale comparative thermal trends over millennial timescales.

The added effect of lower humidity can be estimated from wind chill charts that are calibrated for three standard humidity levels, viz. 70%, 50% and 30%. The higher level corresponds most closely with present-day Tasmanian conditions and assuming a 50% reduction, the lowest level (30%) may be applicable for the LGM. The charts indicate an added wind chill effect of -1°C when relative humidity falls from 70% to 50%, and a -2°C adjustment when it falls from 70% to 30% (http://www.bom.gov.au/olympic/chillindex.htm).

Lower air temperatures in late Pleistocene Tasmania, coupled with reduced relative humidity and stronger wind speeds, signify wind chill levels that approach physiological limits. At an air temperature of 0°C, a moderate breeze (10-20 km/hr) results in effective temperatures around -5°C. Stronger winds (30-40 km/hr) create effective temperatures around -10°C. Such conditions exceed the safe limits allowed by all known physiological cold adaptations, and are dangerous for exposed humans, requiring prompt behavioural responses. Strong winds render basic forms of protection, such as open fires and draped animal skin garments, less effective, meaning that access to shelter became a more serious issue for humans in the LGM.

## Thermal environments

Thermal conditions in prehistoric Tasmania are assessed by first summarising meteorological data for the historical period, then examining the evidence for past climatic changes since the earliest known human occupation of the region around 35 ka.

### *Present*

Meteorological data for Tasmania are presented in Table 24. The records from weather stations span at least 30 years, and sometimes over a century. The four selected stations cover the southeast (Hobart), southwest (Strathgordon), midlands (Oatlands) and the northern coast (Low

| weather station | Hobart | Oatlands | Low Head | Strathgordon |
|---|---|---|---|---|
| elevation (metres a.s.l.) | 50.5 | 406.0 | 28.0 | 322.0 |
| **Annual** | | | | |
| mean temp °C | 12.6 | 10.2 | 12.8 | 10.1 |
| 9am temp. °C | 12.1 | 9.7 | 12.3 | 9.0 |
| 3pm temp °C | 15.2 | 13.9 | 15.2 | 12.5 |
| mean min. °C | 8.3 | 5.0 | 9.5 | 6.2 |
| lowest min. °C | -2 .8 | -11.7 | -2.8 | -4.1 |
| no. days < 2°C | 14.8 | 85.6 | 8.8 | 44.5 |
| 9am rel. humidity % | 68 | 75 | 80 | 85 |
| 3pm rel. humidity % | 59 | 59 | 73 | 69 |
| 9am wind km / hr | 12.8 | 10.6 | 19.7 | 8.0 |
| 3pm wind km / hr | 15.8 | 14.2 | 22.5 | 10.7 |
| no. days 40-63 km / hr | 21 .9 (av./yr) | 18.9 | 85.3 | 18.6 |
| no. days 40-63 km / hr | 101 (max./yr) | 53 | 169 | 61 |
| no. days > 63 km / hr | 1.3 (av./yr) | 2.3 | 14.8 | 1.6 |
| no. days > 63 km / hr | 14 (max./yr) | 14 | 45 | 8 |
| max. wind km / hr | 150.1 | n/a | n/a | n/a |
| **January** | | | | |
| 9am temp. °C | 16.6 | 14.8 | 16.4 | 12.8 |
| 3pm temp °C | 19.4 | 20.3 | 19.1 | 17.8 |
| mean min. °C | 11.8 | 8.8 | 12.9 | 9.5 |
| lowest min. °C | 3 .3 | -1.5 | 4.4 | 2.8 |
| no. days < 2°C | 0.0 | 0.9 | 0.0 | 0.0 |
| 9am rel. humidity % | 60 | 64 | 73 | 79 |
| 3pm rel. humidity % | 54 | 45 | 68 | 58 |
| 9am wind km / hr | 13.2 | 11.9 | 18.5 | 8.0 |
| 3pm wind km / hr | 18.7 | 15.4 | 23.3 | 11.6 |
| no. days 40-63 km / hr | 1.9 (av./yr) | 1.9 | 6 | 1.1 |
| no. days 40-63 km / hr | 14 (max./yr) | 8 | 23 | 9 |
| no. days > 63 km / hr | 0.1 (av./yr) | 0.3 | 0.9 | 0.1 |
| no. days > 63 km / hr | 1 (max./yr) | 4 | 9 | 2 |
| max. wind km / hr | 127.8 | n/a | n/a | n/a |
| **July** | | | | |
| 9am temp. °C | 6 .9 | 4.3 | 7.9 | 5.2 |
| 3pm temp. °C | 10.6 | 8.2 | 19.1 | 7.9 |
| mean min. °C | 4 .5 | 1.1 | 5.9 | 3.0 |
| lowest min. °C | -2.8 | -7.4 | -2.8 | -4.1 |
| no. days < 2°C | 5.2 | 16.6 | 3.8 | 11.5 |
| 9am rel. humidity % | 79 | 86 | 87 | 91 |
| 3pm rel. humidity % | 65 | 72 | 77 | 80 |
| 9am wind km / hr | 11.9 | 8.2 | 21.0 | 7.1 |
| 3pm wind km / hr | 13.0 | 12.7 | 21.6 | 9.1 |
| no. days 40-63 km / hr | 1.9 (av./yr) | 1.0 | 7.4 | 1.7 |
| no. days 40-63 km / hr | 9 (max./yr) | 4 | 18 | 10 |
| no. days > 63 km / hr | 0.1 (av./yr) | 0.0 | 1.6 | 0.1 |
| no. days > 63 km / hr | 2 (max./yr) | 1 | 10 | 2 |
| max. wind km / hr | 129.6 | n/a | n/a | n/a |

n/a: no reliable data available

*Sources:* Bureau of Meteorology, Commonwealth of Australia (Climate Averages, http://www.bom.gov.au)
Climate & Consultancy Section, NSW Regional Office, Bureau of Meteorology
Ian Barnes-Keoghan, consulting meteorologist, Climate and Consultancy Section, Tasmania and Antarctica Regional Office, Bureau of Meteorology

Table 24 Meteorological data – Tasmania

Head). Noteworthy are the differences between mean annual temperatures and extreme lows. Hobart has a 14˚C difference between mean annual temperature (12.4˚C) and the record extreme low (-2.8˚C). At Oatlands, mean annual temperature is a mild 10.2˚C, but the lowest minimum is more than 20˚C lower (Macphail and Jackson 1978: 287). The lowest temperature ever recorded in Tasmania is -18˚C (Macphail 1979: 309). Also evident is the effect of altitude, reflecting a lapse rate of 0.65˚C/100m (Colhoun 1985a: 45). Notable too are the number of days with minimums below 2˚C, and the number of days each year with strong (> 40km/hr) and gale-force (>63 km/hr) winds. Maximum wind velocities between 130 and 150 km/hr are recorded for Hobart, but reliable data on maximum wind strength for the other stations are not available.

Wind patterns in Tasmania are dominated by prevailing westerly airstreams, stronger than at comparable latitudes in the northern hemisphere (Lamb 1959). Seasonal and regional variations are marked. North-westerly winds are common in the east and north of the island, but colder south-westerly winds, sometimes gale-force, are more frequent in the southwest, especially in winter (Nunez 1978).

Classed as a cool temperate climate, the historical Tasmanian thermal environment is typified by sustained periods of cold weather, strong winds, and generally moderate to high rainfall and humidity levels. Also, there are occasional colder spells characterised by near-zero temperatures, falling to around -5°C at the higher elevations. During the LGM, the Antarctic Convergence Zone moved northward by 5-6° of latitude, resulting in colder and probably windier conditions throughout Tasmania, although cold outbreaks may have been less frequent due to inhibition of such incursions by more stable high-pressure cells over the continent (Derbyshire 1971: 116). These cold outbreaks occur on average a few times a year, and are most common in late winter and early spring (Pierrehumbert 1962). They arise when synoptic conditions allow a surge of polar air from the south or sometimes from the west, over the Great Australian Bight (Simmonds and Rashid 2001, Jones 2003).

*Past*

Relevant palaeoenvironmental data can be divided into four categories: geomorphology, isotope geochemistry, palynology, and sea level studies.

Geomorphology

With its rugged topography and cave-bearing karst formations, the west offers greater natural protection from wind-chill compared with the northern and eastern regions of Tasmania. The north-south orientation of the main valley structures is advantageous in this regard, giving added protection from the dominant westerly airstreams (Walker 2003). During the LGM, the snowline was lowered by 1000m, which translates into a fall in average temperatures of around 6.5˚C (Colhoun 1985a: 47-48). There is no evidence for permafrost (Davies 1967: 12), indicating that mean annual temperatures remained above -2˚C, although seasonal deep freezing of the ground surface is shown by fossil wedge-shaped structures at Rocky Cape (Colhoun 1977a: 25). Maximum ice development is dated geologically to 21-20 ka, followed by rapid deglaciation, which was complete by 14 ka if not earlier (Colhoun, in prep: 4). Exposure dating of frost-shattered blocks places peak periglacial activity in southeastern mainland Australia at 22 ka, with a possible second smaller peak around 17 ka, which may reflect a "reactivation event due to cooling after the LGM" (Barrows *et al*. 2004: 10).

Geomorphological evidence points to drier as well as colder conditions during the late Pleistocene in southern Australia, including Tasmania, with average precipitation as low as 50% of present-day levels; seasonal regimes may have been accentuated, with most rainfall occurring in winter (Galloway 1965: 613-614, Colhoun, pers. comm.). Low relative humidity levels exacerbate the wind chill effect, while wet conditions reduce the thermal effectiveness of clothing, so shelter from rain as well as wind would be important, especially in the winters. The driest conditions may have prevailed in the post-LGM period from 19 - 14 ka (Macphail and Colhoun 1985: 45, Chappell 2003, Kershaw *et al.* 2003).

Aeolian sand sheets and dune formations from the last glacial are found in river valleys and coastal areas of Tasmania (Nicholls 1958, Kershaw and Sutherland 1972, Colhoun 1977b, Sigleo and Colhoun 1982). These result from drier conditions when reduced forest cover favoured surface instability and deflation, and prevailing winds were "particularly severe as the westerly wind belts moved northwards during Glacials" (Sutherland and Kershaw 1971: 171). The LGM climate inferred from aeolian features, is strongly seasonal, windy, and semiarid, with winters dominated by "intensified late Last Glacial airflows" (Sigleo and Colhoun 1982: 115-116).

Average wind velocities and directions in Tasmania during the late Pleistocene have been estimated from a study of dunes in northeastern Tasmania, indicating that prevailing westerly wind velocities were 8-10 km/hr higher than at present (Bowden 1983: 163-169). Extrapolating from records at the Low Head meteorological station, the average velocity of westerly winds was calculated to have increased from 27 km/hr to 36 km/hr (ibid). Colhoun suggests that LGM winds may have been substantially stronger than Bowden's estimate (Colhoun, pers. comm.). In brief, the geomorphological evidence from Tasmania points to markedly colder, drier, and windier conditions during the LGM. It also highlights the availability of natural shelter, particularly in the southwest, comprised of valley systems orientated so as to oppose prevailing winds, within which there exist numerous caves and rockshelter formations.

Isotope geochemistry

The application of the thermodynamic properties of isotopes to the study of past temperatures (Urey 1947: 580-581) has led to the construction of generalised global temperature curves. These show major oscillations in ocean surface temperatures since the beginning of the Pleistocene nearly two million years ago. The alternating warm and cold cycles are assigned odd and even numbers respectively, commencing with the present interglacial, stage 1, 10-0 ka (Emiliani 1966). The last warm interglacial occurred early in stage 5, between 128 and 118 ka. Stage 3 is a milder interval occurring between the two cold periods, stage 4 (74-60 ka) and stage 2 (28-10 ka), with the latter including the LGM. Stage 3 became progressively colder after 40 ka, almost as cold as some earlier glacial episodes, and stage 2 was very cold throughout (Emiliani and Shackleton 1974: 511). Glacial cycles have been linked to cyclical variations in the earth's orbital geometry, and to changing sea levels associated with fluctuations in ice volume, leading to more refined chronologies (Hayes et al 1976, Chappell and Shackleton 1986: 137).

Isotope data covering the past 75 ky for Tasmania were obtained from a deep-sea sediment core, located some 50 km west of Macquarie Harbour. However, dating was indirect, by correlation with a core from the southwestern subpolar Indian Ocean, where the chronostratigraphy has an error of ±5000 years (Martinson et al 1987: 18-19). Using this chronology, temperatures between 35 and 25 ka were comparable to those of stage 4, followed by a marked decline towards the lowest point, put at 18 ka (van de Geer *et al.* 1994: 35).

Oxygen isotope and other proxy palaeotemperature indicators from the Vostok ice core in Eastern Antarctica show falling temperatures during stage 3 and into stage 2 (Blunier et al 1998: 741, Petit et al 1999: 431). Deuterium isotope curves from Dome C and other East Antarctic ice cores are relatively flat between 28 and 19 ka (Jouzel et al 2001: 3200, EPICA 2004: 624), consistent with a long and uniformly cold LGM. Most of the isotope curves for the latter part of stage 2 show a steady warming trend from 19 ka, interrupted by a pause around 15-14 ka, known as the Antarctic Cold Reversal (ACR), with an early Holocene maximum around 11-9.5 ka (Morgan et al 2002: 1863-1864). At Siple Dome, the deuterium isotope record shows very low temperature readings from 30 ka, reaching a minimum at 22 ka (Taylor *et al.* 2004: 9).

Isotope curves can be correlated with astronomical parameters of insolation levels based on Milankovitch cycles, facilitating reconstruction of altered seasonality in temperature levels during the Quaternary era (Lamb 1972: 30-38, Berger and Loutre 1991: 297-298). While seasonal variation in precipitation may have been more marked in the late Pleistocene, the variation in solar radiation at middle latitudes between 35 and 20 ka was broadly comparable to the late Holocene. This suggests that seasonal variability in mean temperature was also comparable (Mooney 2004), although winter insolation may have been somewhat higher from 35 to 25 ka between latitudes 30°S and 60°S (Berger and Loutre 1991 [ftp://ftp.ngdc.noaa.gov/paleo/insolation/insol91.jun]).

Palynology

Lake Selina in the West Coast Range has yielded the longest pollen record for Tasmania, spanning much of the late Quaternary (substage 5e to stage 1). It shows traces of rainforest species early in stage 3, with sclerophyll scrub and heath progressively displaced by alpine herb vegetation; stage 2 consists almost exclusively of herbs, with traces of woody taxa, and the inferred climate is "cold and glacial" (Colhoun *et al.* 1999: 17). At Tullabardine Dam, the estimated temperature depression is between 4˚C and 5˚C below present late in stage 3, and between 5˚C and 7˚C below present in the first half of stage 2 (Colhoun and van de Geer 1986: 199). Similar findings and temperature estimates have emerged at other Tasmanian locations (Colhoun 1985b, Colhoun and van de Geer 1987, Hopf *et al.* 2000).

Pollen data for mid-latitude regions elsewhere in the southern hemisphere show much the same trends during the late Pleistocene. On the South Island of New Zealand at 42°S, inferred mean temperatures drop steadily after 35 ka to around 4-5˚C below present levels at the glacial maximum

(Moar and Suggate 1979), when the climate was drier with "strong fohn winds" (Moar 1980: 11). In South America at latitude 40-42˚S, tree pollen declines between 35 and 28 ka and is replaced by shrub and herb vegetation (Heusser 1981: 303, 314); mean temperatures remained at least 2-3°C below present from 35 to 15 ka (Heusser 1989:63-65). At Taiquemó (42°10'S, 170m), the pollen sequence suggests minimum temperatures 4°C below present at the LGM, with only small fluctuations (≤ 1˚C) between 31 and 14 ka (Heusser *et al.* 1981: 66).

Aside from providing proxy temperature scales, pollen analyses highlight another aspect of late Pleistocene Tasmanian thermal environments, namely a reduction in vegetation cover. Strong winds may have been one factor restricting tree growth, and the Bassian Plain would have been "extremely exposed except near the few hills, such as the Cave Bay Cave scarp" (Hope 1978: 508). It is suggested that the entire region was treeless for much of the period, although a few pockets of rainforest taxa and eucalypts remained through the LGM, albeit in reduced or dwarfed forms (Macphail and Colhoun 1985, Kirkpatrick 1986: 239, Colhoun 2000: 206, Colhoun and Shimeld, in prep.).

This loss of vegetation cover has thermal implications, since the height and density of vegetation affects wind penetration to ground level. Tall and/or dense vegetation not only helps retain ground warmth at night but also, in itself, provides protection from wind. The Australian Bureau of Meteorology does not produce wind chill data, in part because measured wind speeds are "very sensitive" to the presence of ground features such as forests that "cause frictional drag on moving air masses, resulting in much lower wind speeds than over open, cleared areas" (C Skinner, Bureau of Meteorology, Melbourne, pers. comm.). Studies have shown that with a dense tree belt of height *H*, there is a significant reduction in wind speed at a distance up to around 40*H*, and within 5*H* conditions are typically almost calm (Jensen 1954: 159-220, Griffiths 1976a: 51). The warming effect of forest cover on ground conditions is similar to that of body fur on the skin of mammals, reducing air motion near the surface. A treeless landscape is effectively denuded, resulting in greater exposure to wind chill. In addition, it reduces the availability of firewood. Shelter becomes more important not only in making effective use of fire for personal warmth, but also in protecting fire from the wind. Moreover, most of the artificial shelters used by Tasmanian Aborigines required floral resources, especially branches and bark from trees. For all these reasons, loss of tree cover restricted human behavioural options with regard to protection from cold and particularly from wind chill during the LGM – at the very time when the physiological need for protection was most acute.

Sea level studies

Data relating to the regional and local late Pleistocene situation comes from the Huon Peninsula in New Guinea and from locations off the southern and northwestern coasts of Australia. Huon Peninsula data indicate falling sea levels between 40 ka and the lowest point at 20-18 ka, with subsequent revisions pointing to the possibility of very low sea levels from around 35 - 30 ka (Chappell 1983: 101, Bard *et al.* 1990: 458, Chappell *et al.* 1996: 228). The Bass Strait land bridge may have been submerged briefly at times but otherwise it remained open, with sea levels more than 55m belowpresent, between 45 and 12 ka (Blom 1988: 96, Lambeck and Chappell 2001: 684); analyses of marine sediments in Gulf St Vincent, South Australia, corroborate this picture (Cann *et al.* 1988: 172-173, Cann *et al.* 1993: 209-210). Findings from Bonaparte Gulf, northwestern Australia, indicate that the lowest sea levels (corresponding to the LGM) pertained from around 30-28 ka through to 20 ka (Yokoyama *et al.* 2000: 714, Lambeck and Chappell 2001: 680, Lambeck *et al.* 2002).

**Summary of palaeoenvironmental data**

These palaeoenvironmental data can be summarised in relation to the main variables affecting thermal conditions for humans in late Pleistocene Tasmania:

1. *Temperature*: average mean temperatures were around 3-4˚C below present between 35 and 30 ka, falling to around 6-7˚C below present between 30 and 20 ka, and remaining at least 3˚C below present until 15 ka. Seasonal variation was probably comparable to the present-day range and, while the difference between average winter minimums and the annual means may have been of similar magnitude, the lowest minimums may have been less extreme relative to the mean annual temperature levels. Relative to the present, average winter and nocturnal minimums were lowered by similar amounts as the mean annual temperatures, i.e. by around 6-7°C during the LGM.

2. *Moisture*: annual precipitation was reduced by up to 50%, and relative humidity may have been lowered by similar proportions. Seasonality may have been greater, with higher winter rainfall relative to the (lower) annual totals. The driest conditions probably occurred between 19 and 14 ka, i.e. somewhat later than the lowest temperatures. Overall, lower humidity would have added to cold stress for humans (althoughreduced moisture levels would make clothing more practicable), and aridity may have exacerbated cold stress despite rising temperatures in the period immediately following the LGM.

3. *Wind velocity*: average wind speeds are estimated at 8-10 km/hr higher than at present, and may well have been higher than this estimate. In combination with the lowered minimum temperatures, stronger winds had a disproportionate impact on wind chill levels, resulting in markedly colder conditions for humans than is suggested by lower temperatures alone.

4. *Vegetation cover*: low-level alpine heath and grassland covered most of the region between 35 and 30 ka.

Between 30 and 20 ka, Tasmania was largely treeless, with a few scattered pockets of forest elements surviving in the southeast and northwest, and possibly in some of the southwest valleys. Forests expanded rapidly after 15 ka, reaching a maximum around 8-9 ka. Reduced vegetation cover during the LGM created a number of thermal problems for humans, of which greater exposure to wind chill and the loss of raw materials for constructing artificial shelters are most pertinent.

## Aims

This study utilises meteorological and palaeoenvironmental data to reconstruct estimated mean annual temperatures and average wind chill levels in Tasmania during the late Pleistocene. Archaeological data on temporal trends in site utilisation are analysed in relation to these estimates, using summary graphs and linear regression analysis. Regional differences in past thermal conditions are examined, using data for locations representing the coastal and the southwest areas. The hypothesised role of wind chill is assessed by assembling data on the direction (or aspect) of the cave and shelter openings, which should manifest a patterning that reflects the need for humans to gain maximum protection from the coldest winds, which in Tasmania's case are those from the southwest.

## Materials

Meteorological data (Table 24) were extracted from records made available by the Australian Bureau of Meteorology (Climate averages, http://www.bom.gov.au). Data comprise mean monthly summer (January) and winter (July) 9am and 3pm temperatures, and mean 9am and 3pm wind velocities for January and July. These were selected from weather stations at Hobart, Oatlands, Low Head and Strathgordon, as being broadly representative of the southeast, midlands, northern coast, and the southwest regions respectively.

Archaeological data (Table 25) comprise dated cave and rockshelter sites in the Tasmanian region for the late Quaternary (35 - 0 ka). For each site, data include the duration of human presence to the nearest 1,000-year (1 ky) interval, elevation (metres a.s.l.), and aspect of the shelter opening, measured where possible from site plans.

Palaeoenvironmental data (Table 26) for the period 35 - 0 ka comprise estimates at each 1 ky interval for mean summer (January) and winter (July) temperatures, wind velocities, humidity levels, and wind chill (making allowance for natural shelter and/or vegetation cover). The figures for the LGM are a maximum reduction of 6.5°C in mean seasonal temperatures, an average reduction in relative humidity by up to 50%, and a maximum increase in average wind velocities of 8-10 km/hr. In Table 26, estimates corresponding to wind chill conditions below -5°C are shown in bold type.

These estimates give only approximate indications. Actual conditions would have varied considerably, including the frequency and severity of more extreme conditions. The wind chill figures nonetheless show that changes in thermal conditions for humans were of significantly greater magnitude than might be suggested by the changes in mean temperatures. Between 35 and 24 ka, for example, while the mean temperature decline is 3°C, the wind chill estimates change by twice this amount. Likewise, in the transition from the terminal Pleistocene to the early Holocene, the amelioration of wind chill (a change of around 10°C) is more dramatic than indicated by mean temperatures.

| | Site | dates (ka) range | elev. (m.) | aspect (compass°) | references |
|---|---|---|---|---|---|
| 1 | Warreen | 35 - 17 | 230 | 065° | Allen 1996b: 144 |
| 2 | Parmerpar Meethaner | 34 - 1 | 300 | 340° | Cosgrove 1995a: 87 |
| 3 | ORS 7 | 31 - 18 | 440 | 020° | Cosgrove 1996a: 72 |
| 4 | Nunamira | 30 - 13 | 400 | 145° | Cosgrove 1996b: 49 |
| 5 | Pallawa Trounter | 30 - 13 | 170 | 255° | Stern & Allen 1996: 172 |
| 6 | Bone Cave | 29 - 14 | 400 | 335° | Allen 1996a: 92 |
| 7 | Cave Bay Cave | 23 - 15 | 25 | 135° | Bowdler 1984: 12 |
| 8 | Beeton Shelter | 22 - 9 | 5 | 335° | Sim 1998: 66 |
| 9 | Mannalargenna | 21 - 8 | 50 | 145° | Brown 1993: 259 |
| 10 | Tiata Mara Kominya | 21 | 400 | (090°) | Goede & Murray 1977: 2 |
| 11 | Kutikina | 20 - 15 | 40 | 350° | Middleton 1979: 71-72 |
| 12 | Maneena Langatick | 20 - 10 | 240 | 045° | Pocock 1993: 242 |
| 13 | Deena-Reena | 19 - 13 | | (360°) | Jones et al 1983: 68 |
| 14 | Piniga Nairana | 18 - 13 | 200 | 290° | Brown et al 1991: 32 |
| 15 | Mackintosh | 17 - 15 | 230 | 115° | Stern & Marshall 1993: 10 |
| 16 | Stone Cave | 17 - 12 | 400 | 290° | Allen & Cosgrove 1996b: 124 |
| 17 | Cliff Cave | 17 | 5 | 195° | Sim 1991: 180 |
| 18 | Wargata Mina | 11 - 9 | | 325° | Goede 1974: 245 |
| 19 | Nanwoon | * | | (045°) | Jones et al 1988: 8 |
| 20 | Ballawinne | * | | 075° | Harris et al 1988: 92 |
| 21 | Artefact Creek W | 14 | 200 | 270° | Brown et al 1991: 33-34 |
| 22 | Warragarra | 11 - 10 | 610 | 070° | Allen & Porch 1996: 197 |
| 23 | Artefact Creek N | * | 200 | 295° | Brown et al 1991: 34 |
| 24 | Artefact Creek T | * | 200 | 305° | Brown et al 1991: 34 |
| 25 | Condominium CC1 | * | 200 | 280° | Brown et al 1991: 32-33 |
| 26 | FNR rockshelter | * | | (270°) | Brown et al 1991: 30 |
| 27 | Rocky Cape South | 8 - 4 | 20 | 120° | Jones 1971: 155 |
| 28 | Sisters' Creek | 6 | 50 | (045°) | Jones 1965: 15 |
| 29 | Point Hibbs | 5 | 3 | 360° | McNiven 1996: 232 |
| 30 | Shag Bay | 5 | 15 | (270°) | Vanderwal 1977: 163 |
| 31 | Rocky Cape North | 5 - 0 | 35 | 295° | Jones 1971: 133 |
| 32 | Louisa River Cave 1 | 1 | 20 | 185° | Vanderwal & Horton 1984: 32 |

*key:* * "late / terminal Pleistocene"
(.....) description only, e.g. "east" = (090)

Additional sources: Stockton 1981, Smith & Sharp 1993, Sim 1994, Anderson et al 1996

Table 25 Archaeological data – Tasmanian cave / shelter sites

## Method

Thermal trends in site utilisation are examined by plotting the number of sites utilised at each 1 ky interval, and the corresponding estimate of mean annual temperature. While archaeological data may not allow time resolution more precisely than one or two millennia (at best), the use of millennial units is said to be a "legitimate" compromise for examining large-scale patterning of human behaviour (Allen 1996a: 120). In this case, these arbitrary intervals may be utilised for identifying trends if the scale of any relationship detected exceeds the uncertainty in site dates. Each site can appear more than once, depending on the number of millennial intervals covered. Kutikina, for instance, is estimated to have been utilised (either continuously, seasonally, or intermittently) throughout a 6 ky period from 20 to 15 ka, so is represented once for each of six intervals designated 20, 19, 18, 17, 16 and 15 ka. For calculation purposes, each of the six sites in Table 25 dated indirectly (but with some confidence) to the late or terminal Pleistocene has been assigned to one of six 1 ky intervals between 17 and 12 ka, to allow for a likely spread of occupation dates and to avoid the statistical distortion that would result from assigning all six to one arbitrary interval, e.g. 14 ka. Pearson correlation coefficients (*r* values) are calculated using SPSS® Graduate Pack 11.0 for Windows for number of sites *vs.* mean temperature change and wind chill, for the total (35 - 0 ka), "pre-LGM" (35 - 20 ka), and "post-LGM" (19 - 0 ka) periods. To correct for the confounding effect of certain thermal levels being more frequent than others between 35 and 0 ka, the total number of sites utilised at each temperature and wind chill level is divided by the number of 1 ky intervals involved (e.g. the glacial maximum temperature change of -6.0 to -6.5°C occurs for eight 1 ky intervals between 26 and 19 ka, so the total number of sites utilised at this temperature level – 66 in this case – is divided by 8, giving an average site occupation rate of 8.25 sites/ky).

Wind chill figures for each 1ky interval are calculated from the meteorological data, using January 9am and July 9am monthly averages for temperature and wind velocity to derive summer and winter estimates respectively at each regional station. Wind velocities are adjusted, however, to allow for the effects of shelter in the form of cave or rockshelter sites and changing vegetation cover. For sites in the southwest zone, the wind chill temperature is approximately equivalent to air temperature, as the wind chill effect is negligible at wind velocities of < 2 m/s, which generally pertains within caves and rock shelters. For coastal zones, exposure to wind chill results from an absence of such protection, due to a paucity of rock shelters and karst formations, and also to a reduction of forest cover, particularly during the LGM. A return of forest cover in the terminal Pleistocene provided a degree of natural shelter in coastal areas, allowing the wind chill effect to be attenuated in the Holocene. Calculations of the Steadman Wind Chill index were performed at the Meteonet (2001) website.

The site aspect data are explored by means of a summary graph, using the data assembled in Table 25. Each site is located on the graph by showing its aspect in relation to the compass directions and also the timing of its utilisation as indicated by available dates. The graph thus depicts patterning of site aspect and utilisation with respect to wind direction and changing thermal conditions over time.

| ka | --- TEMPLATE --- | | --- | Hobart | | Oatlands | | Low Head | | Strathgordon | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | temp △ [°C][1] | wind △ [km/hr][2] | hum △ [rel.%] (effect)[3] | Jan WC[1,5] 9am/3pm | Jul WC 9am/3pm | Jan WC 9am/3pm | Jul WC 9am/3pm | Jan WC 9am/3pm | Jul WC 9am/3pm | Jan WC 9am/3pm | Jul WC 9am/3pm |
| 35 | -3.5 | +4.0 | 70 (0) | 10/12 | 0 / 4 | 9 / 14 | -2 / 1 | 9 /11 | -1/ 2 | 9 /14 | 1 / 4 |
| 34 | -3.5 | +4.5 | 70 (0) | 10/12 | 0 / 4 | 8 / 14 | -2 / 1 | 9 /11 | -1/ 2 | 9 /14 | 1 / 4 |
| 33 | -4.0 | +5.0 | 70 (0) | 9 / 11 | -1 / 3 | 8 / 13 | -2 / 0 | 8 /10 | -2/ 1 | 8 /13 | 0 / 3 |
| 32 | -4.0 | +5.5 | 70 (0) | 9 / 11 | -1 / 3 | 8 / 13 | -3 / 0 | 8 /10 | -2/ 1 | 8 /13 | 0 / 3 |
| 31 | -4.5 | +6.0 | 70 (0) | 9 / 11 | -1 / 2 | 7 / 12 | -3 / 0 | 7 / 9 | -3/ 1 | 8 /13 | 0 / 3 |
| 30 | -4.5 | +6.5 | 50 (-1) | 8 / 9 | -3 / 1 | 6 / 11 | -2 /-1 | 6 / 8 | -4/ 0 | 7 /12 | 0 / 3 |
| 29 | -5.0 | +7.0 | 50 (-1) | 7 / 9 | -3 / 0 | 5 / 10 | -3 /-2 | 5 / 8 | -5/-1 | 6 /11 | -1 / 2 |
| 28 | -5.0 | +7.5 | 50 (-1) | 7 / 9 | -3 / 0 | 5 / 10 | -3 /-2 | 5 / 7 | -5/-1 | 6 /11 | -1 / 2 |
| 27 | -5.5 | +8.0 | 50 (-1) | 6 / 8 | -4 / 0 | 4 / 10 | **-6** /-3 | 5 / 7 | -5/-2 | 6 /11 | -1 / 2 |
| 26 | -6.0 | +8.5 | 50 (-1) | 5 / 7 | -5 /-1 | 4 / 9 | **-7** /-4 | 4 / 6 | **-6**/-3 | 5 /10 | -2 / 1 |
| 25 | -6.0 | +9.0 | 50 (-1) | 5 / 7 | -5 /-1 | 4 / 9 | **-7** /-4 | 4 / 6 | **-6**/-3 | 5 /10 | -2 / 1 |
| 24 | -6.5 | +9.2 | 50 (-1) | 5 / 7 | **-6** /-2 | 3 / 8 | **-7** /-4 | 3 / 5 | **-7**/-3 | 5 /10 | -2 / 1 |
| 23 | -6.5 | +9.2 | 30 (-2) | 3 / 6 | **-7** /-3 | 2 / 7 | **-8** /-5 | 2 / 4 | **-8**/-3 | 4 / 9 | -2 / 1 |
| 22 | -6.5 | +9.2 | 30 (-2) | 3 / 6 | **-7** /-3 | 2 / 7 | **-8** /-5 | 2 / 4 | **-8**/-3 | 4 / 9 | -2 / 1 |
| 21 | -6.5 | +9.2 | 30 (-2) | 3 / 6 | **-7** /-3 | 2 / 7 | **-8** /-5 | 2 / 4 | **-8**/-3 | 4 / 9 | -2 / 1 |
| 20 | -6.5 | +9.2 | 30 (-2) | 3 / 6 | **-7** /-3 | 2 / 7 | **-8** /-5 | 2 / 4 | **-8**/-3 | 4 / 9 | -2 / 1 |
| 19 | -6.0 | +9.0 | 30 (-2) | 4 / 6 | **-6** /-2 | 3 / 8 | **-8** /-5 | 3 / 5 | **-7**/-3 | 4 / 9 | -2 / 1 |
| 18 | -5.5 | +8.0 | 30 (-2) | 5 / 7 | -5 /-1 | 3 / 9 | **-7** /-4 | 4 / 6 | **-6**/-3 | 5 /10 | -1 / 2 |
| 17 | -5.0 | +7.0 | 30 (-2) | 6 / 8 | -4 /-1 | 4 / 9 | **-6** /-3 | 4 / 7 | **-6**/-2 | 5 /10 | -1 / 2 |
| 16 | -5.5 | +6.0 | 50 (-1) | 7 / 8 | -4 / 0 | 5 / 9 | -5 /-2 | 5 / 7 | -5/-1 | 6 /11 | -1 / 2 |
| 15 | -5.5 | +5.0 | 50 (-1) | 7 / 9 | -3 / 0 | 5 / 9 | -5 /-2 | 5 / 7 | -5/-1 | 6 /11 | -1 / 2 |
| 14 | -4.5 | +4.0 | 50 (-1) | 8 /10 | -2 / 2 | 6 /12 | -4 /-1 | 7 / 9 | -1/ 1 | 7 /12 | 0 / 3 |
| 13 | -3.5 | +3.0 | 50 (-1) | 10/13 | 0 / 4 | 8 /14 | -3 / 1 | 10/12 | 1/ 4 | 8 /13 | 1 / 4 |
| 12 | -2.5 | +2.0 | 70 (0) | 12/15 | 2 / 6 | 10/16 | -1 / 3 | 12/15 | 5/ 8 | 10/15 | 2 / 5 |
| 11 | -1.0 | +1.0 | 70 (0) | 15/18 | 5 / 9 | 13/19 | 2 / 6 | 15/18 | 6/ 9 | 11/16 | 3 / 6 |
| 10 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |
| 9 | +0.5 | 0.0 | 70 (0) | 17/19 | 7 /10 | 15/20 | 4 / 8 | 16/19 | 8/11 | 13/18 | 5 / 8 |
| 8 | +1.0 | 0.0 | 70 (0) | 17/20 | 7 /11 | 15/21 | 5 / 8 | 17/20 | 8/11 | 13/18 | 5 / 8 |
| 7 | +0.5 | 0.0 | 70 (0) | 17/19 | 7 /10 | 15/20 | 4 / 8 | 16/19 | 8/11 | 13/18 | 5 / 8 |
| 6 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |
| 5 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |
| 4 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |
| 3 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |
| 2 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |
| 1 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |
| 0 | 0.0 | 0.0 | 70 (0) | 16/19 | 6 /10 | 14/20 | 4 / 7 | 16/19 | 7/10 | 12/17 | 4 / 7 |

*Notes:* 1. mean monthly temperature difference cf. present, assuming conservative estimates for the "long" LGM, a small Antarctic Cold Reversal (ACR) c.15 ka, a "climatic optimum" c. 9-7 ka, and present-day seasonality;
2. estimated change in average wind velocity, using Bowden's estimate (+9.2 km/hr) for the glacial maximum, and scaled for other 1 ky intervals;
3. allowance for adjustment of wind chill due to estimated changes in average humidity, using the standard humidity levels of 30%, 50% and 70%, with 70% approximating the present and a maximum reduction by approximately 50% (to 30%) during the LGM;
4. wind chill (Steadman formula), calculated using estimates for mean monthly 9am and 3pm temperatures ([1]) and average monthly 9am and 3pm wind velocities ([2]), assuming minimal wind velocity (2m/s, or 7.2 km/hr) at cave / shelter sites, and reduced wind chill after 15 ka at all locations due to return of forest cover (to a maximum of 4 m/s [14 km/hr] for 13-12 ka and 2 m/s [7.2 km/hr] for 11-0 ka);
5. wind chill levels below a probable physiological cold "threshold" of -5°C are shown in bold type.

Table 26 Palaeoenvironmental data 35 - 0 ka

# Chapter 10 Results and Discussion

## Results

The upper scale in Figure 59 shows site distribution in time. Site numbers begin to increase from 35 ka, and especially around 30 ka and after 24 ka, reaching a maximum at 17 ka. Site numbers decline steadily from 17 to 10 ka, pausing in the terminal Pleistocene, with a few cave sites outside the southwest being utilised at times throughout the Holocene. The rate of change in site numbers differs somewhat on either side of the 17 ka maximum, being more gradual entering the LGM, while the decrease in site numbers is comparatively rapid after 15 ka. In the lower part of Figure 59, the mean temperature trend is plotted on the same timescale. An inverse relationship between site utilisation and temperature is apparent, as is a "lag" effect in the immediate post-LGM period around 17 ka.

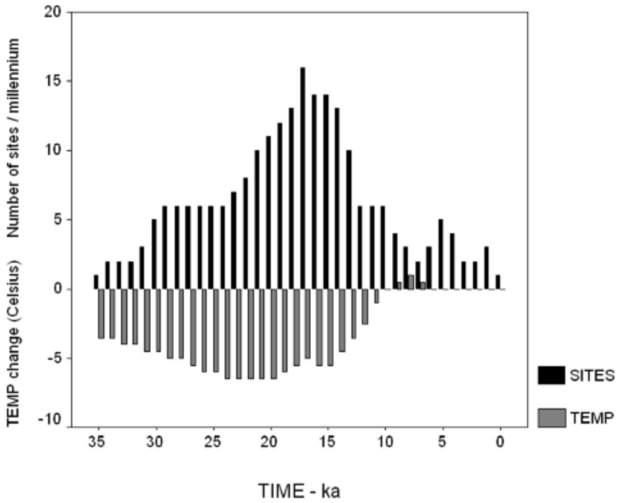



Figure 59 Site utilisation: thermal trends

Figure 60 shows these thermal trends in site numbers independent of time. Using the wind chill estimates for Strathgordon (January 9am) in Table 26, a total of 10 temperature levels (ranging from 4° to 13°C) occur over the 36 millennial intervals between 35 and 0 ka. The total number of sites utilised at each wind chill level is the sum of sites utilised at all of the 1ky intervals having the same temperature estimate. For example, the mean temperature level of 6°C comprises five intervals, *viz.* 29 ka (6 sites utilised), 28 ka (6 sites), 27 ka (6 sites), 16 ka (14 sites) and 15 ka (14 sites), which gives a total of 46 sites at the 6°C wind chill level. The frequency distribution of wind chill levels is skewed by an over-representation of warmer levels, reflecting the high number of millennial intervals with a 12°C wind chill level in the Holocene, resulting in a disproportionate number of sites at this level despite comparatively low site utilisation rates.

This distorting effect can be corrected by examining average site utilisation rates. The average number of sites (Figure 61) is calculated by dividing the number of sites at each wind chill level by the number of millennial intervals involved. For instance the number of sites at 6°C (46) is divided by 5, giving an average site utilisation rate of 9.2.

Given the different rates of change in site utilisation on either side of the LGM, separate results are shown for the 35-20 ka and 19-0 ka periods (Figures 62 and 63). In all these graphs, there is an inverse thermal trend in the utilisation of sheltered sites. This becomes most evident in the period following the LGM (Figure 63), for which the most data exist in terms of the numbers of millennial intervals and sites used in the analyses.

Figure 64 shows correlation results using the Strathgordon data. For the entire 35-0 ka period, the Pearson correlation coefficient between mean annual temperature level (to the nearest degree Celsius) and the total number of sites in each temperature category is -.772 (Figure 64a). Using separate analyses for the periods entering and exiting the LGM (i.e. before and after 20 ka), the correlations are -.947 and -.946 (Figures 64b and 64c respectively).

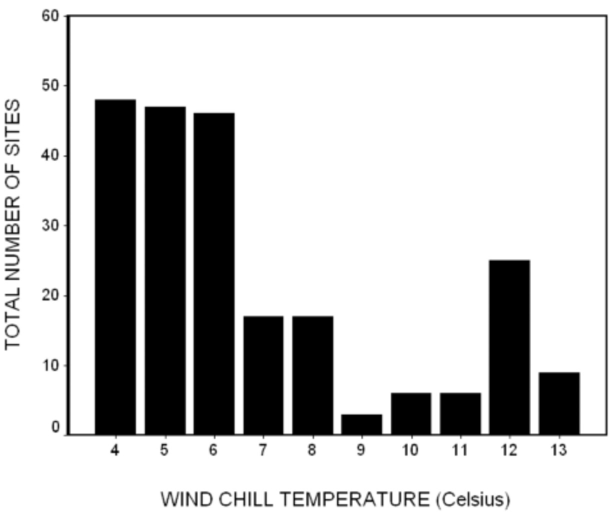



Figure 60 Site utilisation: thermal trends

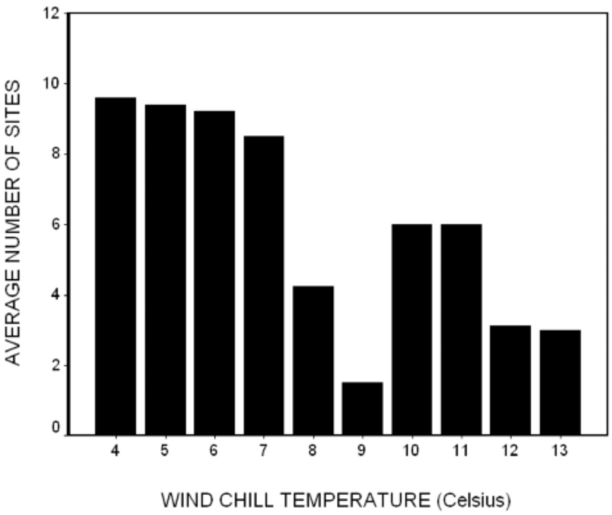



Figure 61 Average number of sites 35 - 0 ka

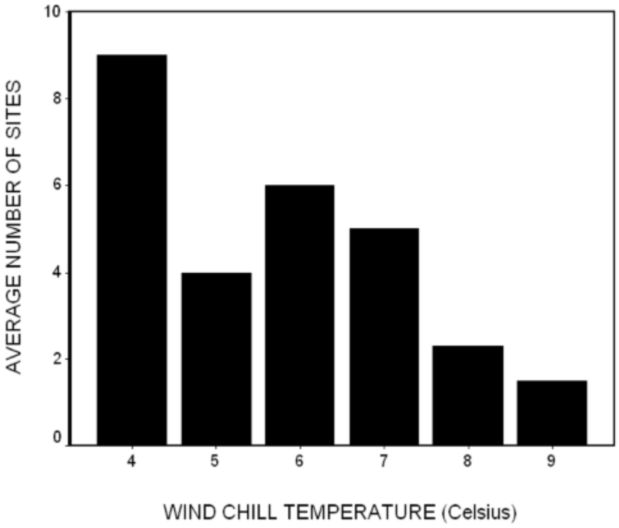



Figure 62 Average number of sites 35 - 20 ka

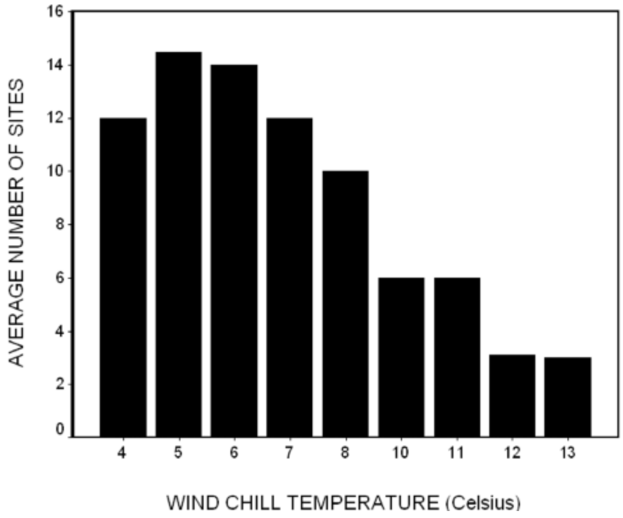



Figure 63 Average number of sites 19 - 0 ka

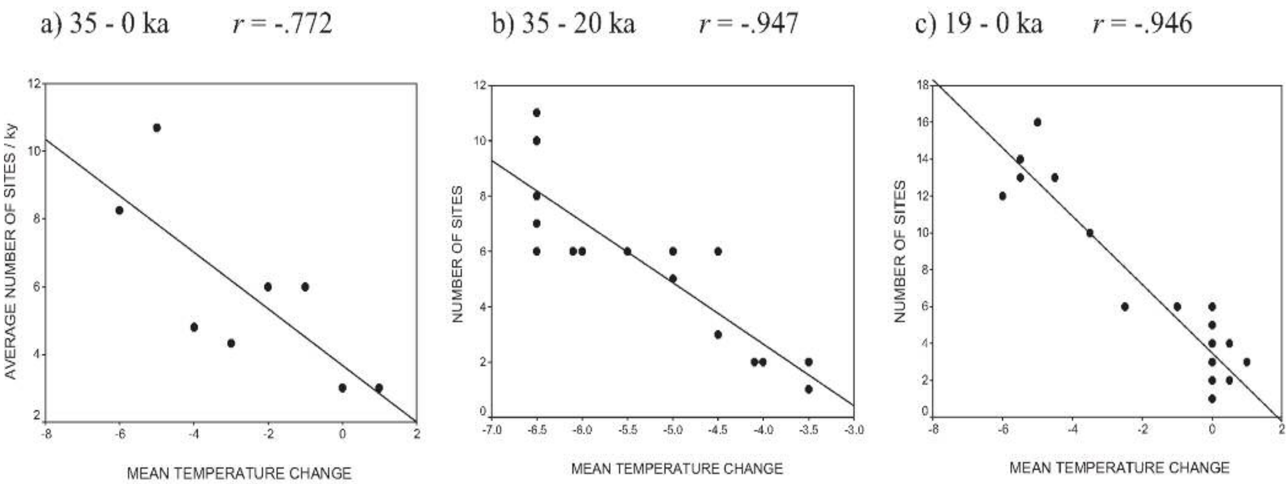



Figure 64 Correlation results – mean annual temperature

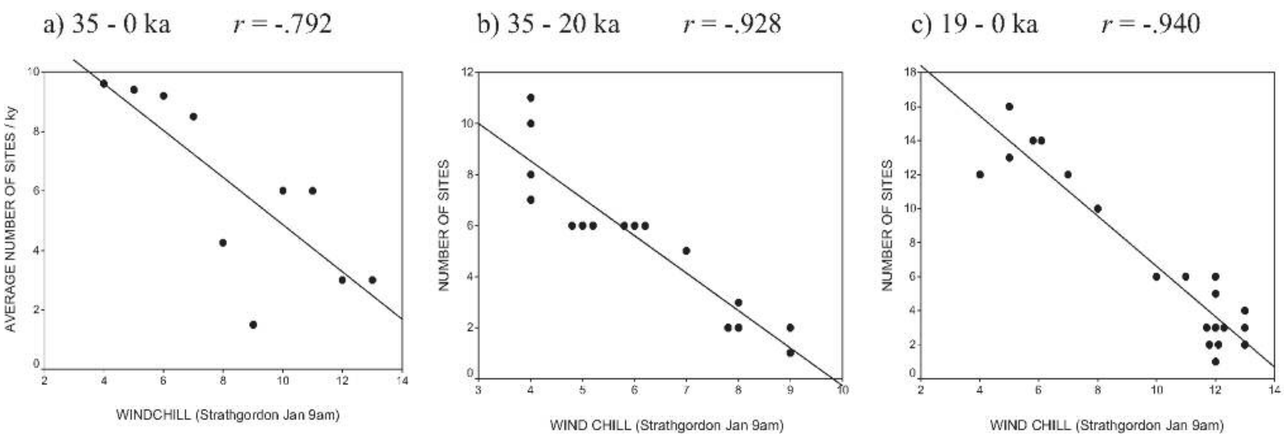



Figure 65 Correlation results – wind chill

Calculations were also performed using the wind chill estimates (Figure 65). For 35-0 ka, the correlation between site numbers and wind chill (using Strathgordon January 9am figures) is -.792, increasing to -.928 and -.940 for the 35-20 and 19-0 ka periods. Results using wind chill figures for 9am and 3pm January and July data from all four meteorological stations were of similar magnitude. All correlations are highly significant at the 0.01 level (2-tailed).

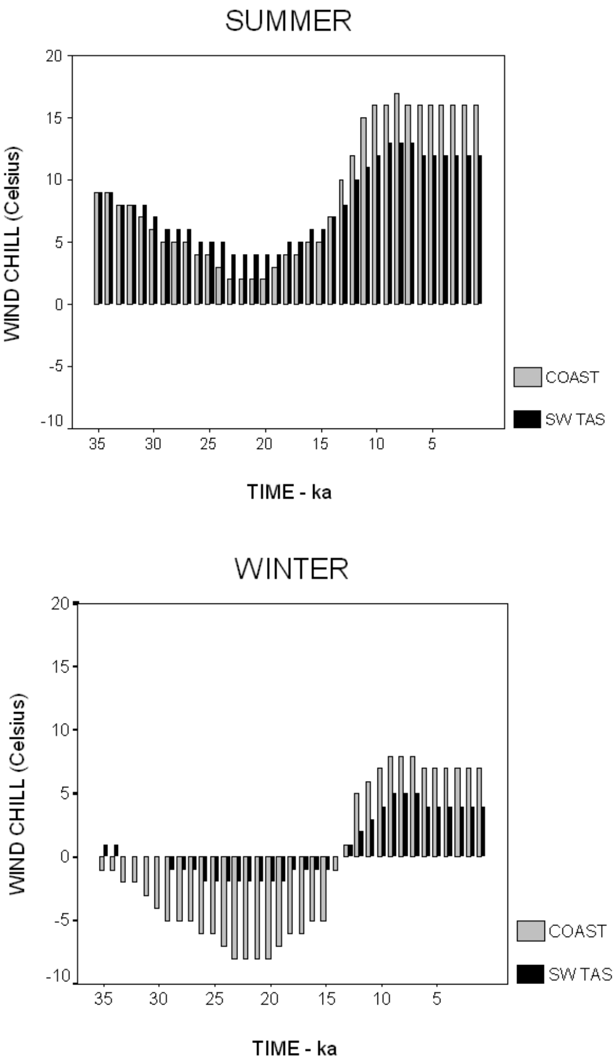



Figure 66 Wind chill: regional and seasonal trends

Figure 66 shows the regional and seasonal trends in thermal conditions. Wind chill estimates are plotted for summer (Figure 66a) and winter (Figure 66b) on a 35 - 0 ka time axis. Results for Strathgordon and Low Head only are shown, to highlight regional (i.e. southwest *vs.* coastal) and seasonal trends in Tasmania between 35 and 0 ka:

a) *summer*: throughout the Holocene, the present-day northern coast is warmer than the southwest, whereas in the late Pleistocene, the southwest is warmer, though in neither region do thermal conditions fall below a temperature equivalent of 0°C;

b) *winter*: during the Holocene the coast is warmer, whereas in the late Pleistocene the southwest is warmer, and at Low Head thermal conditions during the LGM fall below -5°C.

Figure 67 shows site aspect findings, where the aspect of each site is plotted against the compass axes. Temporal trends are superimposed, as the same axes can serve as a time scale in two dimensions, with millennial intervals forming concentric circles radiating out from the centre (0 ka) to the periphery (35 ka). Moreover, since mean temperature and wind chill estimates have been derived for each interval (Table 26), thermal as well as temporal trends can be examined. Each site is thus represented as a line in two-dimensional space, with its orientation and length corresponding to aspect and duration of utilisation respectively.

Most sites fall within the northern half of the graph, but an entire sector, corresponding to a S/SW aspect, is virtually vacant. This becomes more striking when it is noted that one of the outliers, site 5 (Pallawa Trounta, aspect 255°), is situated within a doline so as to be "protected from prevailing southwest winds" (Stern and Allen 1996: 171). The other west-facing sites were utilised in the post-LGM period, when temperatures were increasing and the south-westerly winds were not as cold as in the LGM (and, judging from available dates, these sites were utilised over briefer timespans). If sites first utilised prior to 19 ka are considered, and Pallawa excluded, half of the graph – corresponding to a W/SW/S aspect – would be devoid of sites.

Other trends are evident in this graph. As thermal conditions for humans began to deteriorate further from around 30 ka and especially after 25 ka, site utilisation increases markedly, and no sites were abandoned prior to the LGM. Additional sites appear at the glacial maximum around 22-20 ka, with a number being first occupied soon after the LGM, when conditions are thought to be driest. Site utilisation declines rapidly after around 15 ka, reaching a minimum around the time of the "climatic optimum" in the early post-glacial period.

## Discussion

These results suggest that archaeological evidence of changing patterns of human behaviour in late Pleistocene Tasmania can be examined in relation to altered thermal contingencies. Wind chill in particular would have become more significant throughout the cooler southern regions of the Sahul continent. Studies in human physiology point to the existence of thermal thresholds or limits of cold tolerance, beyond which behavioural responses become important for human survival. The fundamental behavioural responses are predictable and include requirements to seek shelter, to manufacture adequate clothing, and to meet greater caloric needs. This study has focussed on the first of these, namely access to shelter in the thermal conditions that prevailed during the LGM in Tasmania.

Palaeoenvironmental and meteorological data have enabled estimates to be derived as to whether LGM conditions approached or exceeded physiological thresholds. Of special concern is the role of wind chill in assessing effective environmental temperatures for humans, and the consequent key function of shelter in reducing the risks associated

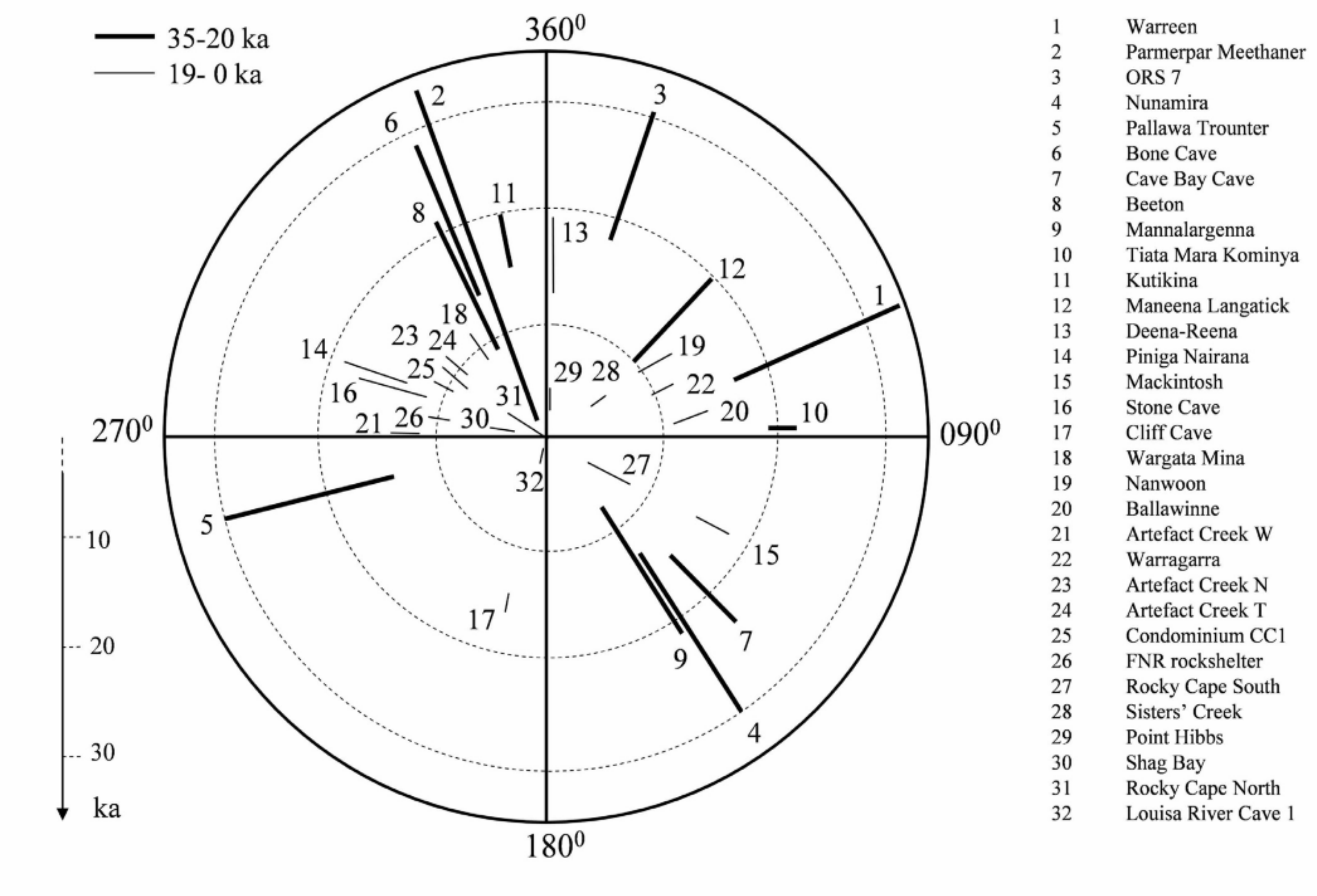



Figure 67 Site aspect results

with cold exposure. Some allowance must be made for enhanced physiological cold tolerance among Australian Aborigines, although this alone is unlikely to have afforded sufficient protection for survival below -5°C. This effective temperature threshold or "limit" was exceeded at times in late Pleistocene Tasmania, at least on a seasonal basis.

Archaeological implications include a useful perspective on, even a possible resolution of, the problem posed by the otherwise puzzling human presence in the remote and rugged southwest region of Tasmania during the late Pleistocene, which witnessed some of the coldest air temperatures seen anywhere in Sahul during the LGM. When the wind chill effect and need for shelter are taken into account, it is not so unexpected that humans began to use the cave and rock shelter locations available at higher elevations in the protected valleys of the southwest.

Seasonal trends in human behaviour might well have been influenced by these thermal considerations. The finding that amelioration of wind chill in the protected valleys and caves of the southwest would have been most crucial in winter is consistent with a number of lines of evidence pointing to winter utilisation of these sites (Cosgrove and Allen 2001: 422). Conditions in the more exposed regions outside the southwest became hazardous in winter but at other times humans could have safely inhabited coastal areas. The coast offered fat-rich faunal resources including seals and seabirds, the exploitation of which could provide high caloric returns, with protein-sparing benefits compared to a lean-meat diet (e.g. Speth and Spielmann 1983: 4).

In early historical times, mutton birds were exploited by Tasmanian Aborigines and also Europeans in Bass Strait, being most readily available during the summer months. Their fat was used for industrial purposes, and a "very large trade" existed in their warm feathers and down (Serventy 1987: 64), with some 2½ tons of down exported from Flinders Island in a single year (Backhouse 1832: 221-222). The feathers could have been used by Aborigines for insulation in shelters, as documented by Robinson at Nye Bay on the southwest coast in 1830, where he found a large circular hut with the walls "stuck full of duck or cockatoo feathers" (Plomley 1966: 139).

Adult fur seals would yield large fur skins for making cloaks, providing superior insulation to wallaby skins. Seal skins could also have been used in lieu of tree bark for artificial shelters, as documented for instance on the west coast of Tierra del Fuego (Darwin 1839: 234). Bones of seal and wallaby were found at the Swashway Saddle open site on the Kent Group of islands in Bass Strait dated to around 9.5 ka (Jones and Lampert 1978: 147, Lampert 2001: 384-385) and fur seal bones occur in the cave (which

faces NW) on Great Glennie Island off Wilson's Promontory in Victoria (Jones and Allen 1979: 6). Judging from faunal remains recovered from the basal levels, seals constituted the "majority" of the meat resources utilised at 8 ka in the South Cave at Rocky Cape, although the relative frequency of seal declines after 4 ka in the North Cave (Jones 1967: 362-363).

Similarly, seals dominate the faunal record of animal remains at Louisa Bay, dated to around 1 ka, with fur seals being "largely a summer resource", and they were the "overwhelming reason" for making the dangerous open water crossing to nearby Maatsuyker Island, where mutton birds were also exploited (Vanderwal and Horton 1984: 96-98). Remains of the southern elephant seal have been recovered from the West Point Midden on the northwest Tasmanian coast, dated to the late Holocene, when they were exploited on a year-round basis by Tasmanian Aborigines, although mainly juveniles were available for human predation outside the summer season (ibid, Bryden *et al.* 1999). Fur seal bones were recovered from a midden dating to 600 BP on Rakiura (47°S), south of New Zealand's South Island, and seal skins were used as garments by the Maori on these subantarctic islands in historical times (Anderson and Regan 2000: 441-447).

Whether humans moved on a seasonal basis between inland and coastal areas during the LGM, favouring the coast in summer, may never be known, as any occupation sites along the available coastline were lost to rising sea levels in the terminal Pleistocene. Not only would this scenario be the reverse of the ethnographic pattern observed for Tasmanian Aborigines in the late Holocene, when the coast was favoured in winter, it runs counter to Jones' "guess" that seasonal exploitation of the southwest valleys during the late Pleistocene consisted of "summer hunting trips" (Jones 1987a: 38, see also Goede and Murray 1977: 9). Year-round occupation of the highlands was also feasible, but the proximity of coastal areas that were habitable on a seasonal basis, and which offered abundant and reliable resources for meeting human nutritional and thermal requirements, particularly from spring to autumn, renders this option less likely.

There has been some debate as to whether archaeological evidence suggests that sites at higher elevations may have been abandoned due to increased cold stress during the more severe thermal conditions of the LGM (e.g. Porch and Allen 1995: 721). For instance, radiocarbon determinations and stratigraphic considerations at Warreen Cave (230m a.s.l.) may hint at "a short hiatus in occupation" between 22 and 20 ka, although the overall pattern is of "more-or-less continuous" human usage throughout the LGM (Allen 1996b: 158-165). However at Bone Cave (400m a.s.l.) there is a clear break in the occupation sequence between 23 and 17 ka. The archaeological resolution is insufficient to determine whether there was "total abandonment", but it does seem "more than chance that this period of minimal deposition should coincide with the period of maximum cold" (Allen 1996a: 114). Allen notes that sites at lower elevations show "continuity of occupation" through the LGM, although he suspects that "we are less likely to be looking at the limits of human tolerance to cold than at delicate alterations to the wider ecosystems" – though he does not speculate as to the possible nature of these ecosystemic alterations, and concedes it is unlikely that "availability of the principal game animals would have changed much during this period" (ibid).

The adjacent Stone Cave (400m a.s.l.) was utilised in the post-LGM period around 17 - 12 ka and shows a comparatively even distribution of artefacts over time (Allen and Cosgrove 1996b: 129). At the rockshelter site ORS7 (440m a.s.l.), there is a reduction in discard rates of stone artefacts approaching 20 ka (Cosgrove 1996a: 84-85). At Nunamira Cave (400m a.s.l.), there is a gap in radiocarbon determinations on charcoal derived from hearths between 21 and 16 ka, although lack of rubble in the cave attributable to frost action – seen for instance at Kutikina (40m a.s.l.) – is cited as evidence against temperatures being "extremely low", despite the higher elevation of Nunamira (Cosgrove 1996b: 63-65). Like Bone Cave, the Nunamira evidence hints at reduced utilisation if not abandonment of sites at higher elevations around 20 ka (Allen 1996a: 121). Discard rates at Parmerpar Meethaner (300m a.s.l.) reveal a distinct fall around 21 ka (Cosgrove 1995a: 99) and also at the Pallawa Trounter shelter (170m a.s.l.), where there is a gap in radiocarbon determinations between 22 and 18 ka (Stern and Allen 1996: 184-186). Of the sites at higher elevations, only Tiata Mara Kominya (400m a.s.l., known formerly as Beginners Luck Cave) has a possible date of around 21 ka (Smith and Sharp 1993: 39). This site yielded just two stone flaked tools and a bone spatula, and the original radiocarbon date from associated breccia was 13 ka (Goede and Murray 1977: 7).

The possible thermal relationship between site elevation and utilisation rates during the LGM should certainly be "further explored" (Allen 1996a: 114) although Allen, echoing Bowdler's remarks (Bowdler 1984: 130), cautions against any "simplistic equation of the cold exceeding human tolerance at the height of the Last Glaciation" (Allen 1996a: 120). Notwithstanding the interesting trends, it would appear at this stage that neither the archaeological nor the palaeoenvironmental data provide sufficiently fine resolution to properly address this question. It can be noted that while differences in elevation of a few hundred metres equate with mean temperature differences of only "a few degrees Centigrade" (Cosgrove 1999: 368), and these may be of little concern above physiological thresholds of human cold tolerance, small differences become more critical as threshold levels are approached. With a lapse rate of 0.65°C/100m, the difference in elevation between 200 and 400m translates into a mean temperature difference of 1.3°C, rising to around 2°C with wind chill. This could equate to the difference between -5°C and -7°C, or between -6°C and -8°C. Such suggestions need not be construed as environmentally deterministic, nor should

they be dismissed as implying that human behavioural shifts occurred "merely at the whim of nature" (Porch and Allen 1995: 729).

Depending on the development of other thermal adaptations, both morphological and cultural (the latter referring especially to the form of clothing), humans in late Pleistocene Tasmania may have experienced sufficient thermal stress at some periods during the LGM to render shelter sites at higher elevations less habitable. This may have been the case particularly around the time of maximum glaciation, around 22 -20 ka, when a difference in mean annual temperatures of just a few degrees Celsius due to the higher elevation could become critical. If so, shelter sites at lower elevations (e.g. below 200-300 metres a.s.l.) would be favoured, and may even show indications of more intense site utilisation.

Other archaeological issues relate to the major change in predominant site type between the late Pleistocene and the Holocene, i.e. open *vs.* sheltered sites. The paucity of Pleistocene open sites may largely reflect poor site visibility, with coastal sites now submerged and those in the southwest covered by dense vegetation, although no open sites have been found even in those southwest areas where ground visibility is good (Cosgrove et al 1994: 31). Archaeological sites described as "open" need not necessarily imply a total lack of shelter, as artificial windbreaks and other forms of protection from wind could have been erected at such sites, made for instance from tree branches and bark (Attenbrow 2002: 106), or perhaps more likely in the case of coastal Tasmania during the late Pleistocene, large animal skins such as those of seals. Even dune and midden sites can in themselves provide a degree of shelter from winds (Jones 1967: 359) with aeolian dunes in particular, being formed by prevailing winds, offering some protection on their leeward slopes. Locations such as the Rushy Lagoon lunette (dated to 8 ka) on the northeast Tasmanian coast (Cosgrove 1985) and Palana (dated to 7 ka) on the northwest coast of Flinders Island (Orchiston and Glenie 1978) could have provided a degree of natural shelter. Protection from wind chill at such locations could have been augmented by the use of animal skins, and also by excavation of hollows, as documented by Robinson on the west coast near Sundown Point in 1833 (Plomley 1966: 790), and there are suggestions of a late Pleistocene human presence at Rushy Lagoon (Cosgrove 1985: 32).

The need for shelter during winter does not preclude the use of open sites in the southwest when conditions were benign, and many cave sites have lithic discard rates suggesting only sporadic human use throughout much of the late Pleistocene. This is especially true for the glacial maximum around 22-20 ka, when some sites appear to show an occupation hiatus. Given that thermal conditions elsewhere in the Tasmanian region were more challenging (notably on the exposed Bassian Plain to the immediate north, which may have restricted any retreat to lower latitudes), this raises the possibility that humans were effectively isolated in Tasmania for much of the last 30,000 rather than 10,000 years, perhaps with a "window" opening in the terminal Pleistocene as conditions improved between 15 and 12 ka, before the land bridge was inundated. It also raises the spectre of a local decline in human population levels due to thermal stresses around the time of the glacial maximum. The palaeoenvironmental estimates show that conditions in the north became inhospitable earlier than in the south (comparing Low Head and Hobart between 30 and 25 ka in Table 26), suggesting paradoxically that humans gravitated southwards rather than northwards as thermal conditions deteriorated, retreating to the more protected southwest during the winters.

One interesting trend evident from the site utilisation results is the increased rate of site utilisation after 24 ka. This could reflect a number of thermal factors, one being higher wind velocities after 25 ka having a disproportionate effect on wind chill levels. Combined with the lower humidity estimates from 23 to 17 ka which would exacerbate wind chill, both of these factors tend to lag the lowest mean temperatures. Such considerations may contribute to the delay in maximum site utilisation until immediately after the LGM, with the peak occurring at 17 ka and high rates continuing until 13 ka. To some extent this could also reflect "cultural lag", while another factor could be the possibility of reduced physiological cold tolerance among humans due to their effective use of fire, shelter and clothing during the LGM.

As mentioned above, with the exception of Pallawa Trounta, all of the sites in the W/SW/S half of the site aspect graph (Figure 67) post-date the LGM. Of these, almost all face west or north-west. While this leaves them more exposed to westerly and south-westerly winds compared to sites facing north or east, one advantage of a site facing west is that it catches the afternoon sun. Aside from the wind chill effect, these shelters would have been warmer in the evenings, when humans would be seeking protection for the colder nights. After the LGM, when wind chill began to ameliorate towards less critical levels, the thermal effect of afternoon heating by the western sun may have begun to outweigh that of greater wind chill. In this context, it may be observed that nearly all of these sites date to the terminal Pleistocene, when the estimated wind chill levels were rapidly approaching those of the Holocene.

One prominent trend is the decline in southwest site usage at the end of the Pleistocene. It is true that a rapid expansion of dense forests after 15 ka made the southwest less accessible, although rainforest is "extremely" fire-sensitive and it is "perplexing" why it was not kept open by firing (Cosgrove *et al.* 1990: 63, Cosgrove 1995b: 104), even if a "high frequency" of firing (at least once every fifty years) was required (Goede *et al.* 1978: 146). If however, protection from wind chill was a major reason for human utilisation of the southwest in the late Pleistocene, once temperatures increased in the terminal Pleistocene such that critical physiological thresholds were no longer being exceeded, humans could adopt economic strategies and seas-

onal schedules that did not include wintering in the southwest. Coastal regions may well have offered more by way of resources and adaptive options throughout the late Quaternary and presumably these would have been favoured in the late Pleistocene, even in winter, as far as thermal conditions permitted.

With regard to the site aspect findings, protection from wind chill would appear to be the most plausible explanation for the paucity of occupied sites facing to the S/SW. This especially so given the physiological and palaeoenvironmental data indicating that wind chill conditions during the LGM approached the likely cold tolerance limits for humans. Alternative reasons for this pattern in the archaeological data are not readily apparent, although it may generally be expected that north-facing shelters would be preferred in order to maximise light and warmth. Differences in vegetation growth and moisture might also be factors, with south-facing caves being more prone to dampness and moss, though this presumably would affect SE- as much as SW-facing caves. Caves facing S/SW should be no less numerous than those facing other directions, even allowing for the overall north-south trend of the main valley systems whereby shelters facing east or west might be more common; north-facing caves should still be no more commonplace than south-facing caves.

The extent to which otherwise suitable shelters that face S/SW tend to show no signs of human utilisation is difficult to ascertain with available data, as negative findings tend to be under-reported in the literature. The initial surveys of the Gordon and Franklin Rivers showed potential shelter and cave sites facing all directions (Middleton 1979, 1982a, 1982b). At Condominium Cliffs on the Denison River, five suitable rockshelters were found but only two contained cultural material. These two rockshelters face W/NW, whereas the other three all face SW (Brown et al 1991: 31). In a survey of the Nelson River, test excavations were performed at thirteen caves and shelters of which only one (Maneena Langatick Tattana Emita), facing NE, yielded evidence of human occupation. Two of the remaining shelters face east and although the aspect of the others is not reported, most are described as "damp and dark" (Pocock 1993: 241). In the upper Weld Valley, three suitable shelters are located on a dolomite bluff. One is Bone Cave, which faces N/NW and has yielded artefacts in stratigraphic contexts dating between 29 and 14 ka. This cave is "in a sheltered position, with both the cliff in which it is located, and low hills on either side of the river protecting it from the prevailing southwesterly and other winds" (Allen 1996a: 92-93). The second is the adjoining Stone Cave, which has cultural material dating to the post-LGM period 17 - 12 ka. It faces west (290°), and is more "exposed" and its "comparative lack of sunlight and wind protection" may help explain why it was "occupied less frequently" (Allen and Cosgrove 1996b: 124). The third shelter, facing W/SW, was culturally sterile (Allen 1996b: 93).

This study has not addressed other trends that may be related directly or indirectly to thermal parameters. These include issues such as faunal targeting and technological innovations, with the latter including the appearance of so-called "thumbnail scrapers" and bone points. Each is interpretable in relation to thermal adaptations, particularly the use of clothing, and their early appearance and increasing frequency in the archaeological record of southwest Tasmania after 30-28 ka is of interest in view of the long LGM. Some of these trends that may reflect thermal considerations are discussed below in the main Discussion.

The possible influence of thermal contingencies could also be examined in the archaeological records of other regions, such as the southern zones of Australia. Cave and shelter sites were utilised during the late Pleistocene in locations such as Devil's Lair in the southwest corner of mainland Australia (Dortch 1977, Dortch and Dortch 1996), and Clogg's Cave and Birrigai in the southeast of the continent (Flood 1974, Flood *et al.* 1987). It would be of interest to compare data on site utilisation, and site aspect in relation to wind chill estimates, over the whole of Sahul.

In hotter parts of the Australian continent, protection from heat and direct sunlight can be advantageous, as can the cooling effect of wind, and a less skewed distribution of site aspect data might be predicted on thermal grounds, although protection from wind chill would remain relevant in many areas. Analysis of rockshelters in the vicinity of Sydney has shown that while evidence of occupation occurs in shelters facing all directions, some 65% face between NE and NW, "away from the prevailing winds" (Attenbrow 2002: 106). While there is archaeological evidence for Aboriginal habitation of the highland zones of eastern mainland Australia in the late Pleistocene, site utilisation becomes more prominent after the mid-Holocene, and ethnographic records indicate seasonal resource exploitation focussed in the warmer months (Bowdler 1981) - in contrast to the situation in late Pleistocene Tasmania.

Parts of the continent may have served as "refugia" for humans during the more extreme climatic regimes of the late Pleistocene, although this has been mooted more with respect to aridity than temperature (e.g. Smith 1989, Veth 1989). Using number of radiocarbon determinations per 500-year interval as a measure of occupation intensity in southwest Tasmania, Holdaway and Porch (1995) detected a 3 ky cyclical pattern which may correspond with fluctuations in rainfall regimes during the late Pleistocene. It is suggested that coastal adaptations may have been favoured during periods of greater aridity, although an overall trend of increasing utilisation of southwest sites in the late Pleistocene, reaching a maximum at 15 ka, is still evident (ibid: 81).

Comparison with the late Pleistocene archaeological records in middle latitudes of the northern hemisphere was advocated by Jones (1990: 290, see also Cosgrove and

Pike-Tay 2004). Palaeoenvironmental data for Eurasia can be used to evaluate trends such as site utilisation and aspect, faunal targeting, clothing-related technological developments, and geographical limits to human occupation of cold environments. For instance there is evidence for a shift in the pattern of sites occupied during the late Pleistocene in southern Iberia from open air sites to an "increasing use of cave sites, especially in the Upper Palaeolithic" (Finlayson 2004: 169). Thermal conditions however, were less severe in Tasmania after 30 ka than in mid-latitude Eurasia, where mean LGM temperatures declined by around 12°C, and by as much as 15°C below present levels. Sub-zero mean annual temperatures, and winter means below -5°C, signify that wind chill levels exceeded another physiological threshold at middle latitudes in the northern hemisphere. This threshold applies to the minimum clothing requirements for humans. Such conditions require more than two "clo" units of protection (Gagge et al 1941:429) and correspond to the present-day 3-4 layer clothing zones (Siple 1949: 408-420, Griffiths 1976b: 80-81). These demand "complex" clothes (i.e. fitted, multi-layered garment assemblages), as opposed to the "simple" (draped, single-layer garments) that were sufficient in Aboriginal Australia, even during the late Pleistocene. The former have certain technological and archaeological correlates such as dedicated hide-cutting implements (i.e. blade-like tools) along with an ability to inhabit sub-polar and polar latitudes (Gilligan and Walker n.d.). LGM conditions in Tasmania were commensurable more with the northern hemisphere stage 4 rather than stage 2 (cf. Jones 1982: 213, Kiernan *et al.* 1983: 31). It is to this earlier stage that Tasmania can be compared in terms of the conditions to which prehistoric humans became adapted – or not, as the case may be. A review of the stage 3 European palaeoenvironmental and archaeological data may implicate cold stress – directly or indirectly – in the demise of an entire hominid species (Aiello and Wheeler 2003: 156, Gamble 2003, Stringer *et al.* 2003: 238).

This study serves to demonstrate, in preliminary fashion, the value of considering thermal physiology and thermal environments in the interpretation of the archaeological record. It shows how palaeoenvironmental evidence can be used to reconstruct elements of past environmental change that had thermal significance for prehistoric humans. In particular, the existence of thresholds and limits of human physiological adaptations to cold environments has implications for the study of past behavioural patterns. The Tasmanian record presents an ideal opportunity to explore some of these issues, particularly in view of the long LGM, and to make useful comparisons with other regions that may lead to more surprises.

# PART THREE: DISCUSSION

## Chapter 11 Summary and Limitations

### Summary

The Tasmanian clothing paradox arises from ethnographic evidence suggesting that Aborigines in Tasmania at the time of white contact wore less clothing as thermal protection than those in the southern regions of the mainland. This applies both to the type of garments used, and the frequency of use. Prior to white settlement, Australian Aborigines in general were routinely or habitually naked, but the Tasmanian Aborigines, it seems, were even more so, despite a comparatively cooler environment. Even given the typical lack of clothing in Aboriginal Australia, the paucity of clothing among Aborigines in Tasmania has struck many observers as surprising, considering the climate (e.g. Crozet 1772, in Roth 1891: 21).

In some respects, the paradox only arises if it is the case that Aboriginal use of clothing prior to white contact was essentially a thermal behaviour, rather than being mediated also by psychosocial or cultural factors, as applies in contemporary Australia. In addressing the clothing paradox, the aim of the primary study here has been to systematically examine the ethnographic record to establish whether the following two conditions are met:

1. Does the ethnographic record indicate that Aboriginal use of clothing was an essentially thermal adaptation?

2. Does the same record indicate a paradoxical reduction in use of clothes among the Aborigines of Tasmania?

Results of a quantitative analysis of an extensive ethnographic data base indicate that the answer to both questions is "yes". The next question is, given that the Tasmanian clothing paradox is indeed a real phenomenon, what may lead to its resolution?

The ethnographic study raises issues as to human thermal physiology and minimal clothing requirements, and the various factors which may affect these requirements. These include the existence of other thermal adaptations, both biological and cultural. Among the main forms of biological adaptation are morphological adjustments, while cultural (or behavioural) adaptations include the use of fire, shelter, and the application of oils or grease to the skin surface. Any of these factors could prove relevant in attempting to resolve the paradox. Another issue is the possible influence of prior thermal conditions in the development of such adaptations.

To examine these other factors, two additional studies were undertaken in the present work. One is a study of morphological variation in Aboriginal Australians Chapters 7 and 8), and the other (Chapters 9 and 10) looks at thermal conditions for Tasmanian Aborigines in the prehistoric past. Both of these, it is argued, contributed to the paradox, and may allow for its possible resolution.

The second (morphology) study has examined the question of morphological adaptations, using morphometric data (the Birdsell data base) and the available osteological data. The former is largely restricted to the mainland, while the latter allow the incorporation of data for Tasmanian Aborigines. The findings of the Birdsell re-analysis point to significant thermal morphological adaptations within the mainland population. Results of the osteological analyses, while necessarily based on small samples for the Tasmanians, are generally consistent with the development of greater morphological cold adaptations in that population. This, it is argued, may help explain why the Tasmanians could be more "naked" than their counterparts on the southern mainland.

The third (prehistory) study has reconstructed thermal conditions in late Pleistocene Tasmania, looking particularly at estimated wind chill levels. These, it is concluded, approached the likely limits of cold tolerance for exposed humans, at least in winter. This would lead to greater environmental selection for cold adaptations, both biological and cultural. Where pre-existing cultural adaptations were minimal, and where recurrent cold exposure occurred over more than ten millennia, as was the case in Tasmania, the emergence of biological adaptations should be expected. The prehistoric environment, in this scenario, led to more pronounced morphological cold adaptation in Tasmanian Aborigines, and the latter is responsible for the Tasmanian clothing paradox. Nonetheless, the ice age conditions would also presumably lead to cultural or behavioural adaptations, and it can be anticipated that the prehistoric archaeological record will provide evidence of such responses. The prehistory study explores one such aspect, namely the use of shelter in late Pleistocene Tasmania. It concludes that there is indeed evidence that access to shelter became a high priority. The archaeological record might also yield evidence consistent with other behavioural responses, such as greater use of clothing, which would be especially interesting given the clothing paradox.

Before considering some of the wider questions raised by the paradox and its resolution, the findings of the studies themselves are summarised briefly and critically reviewed, particularly with regard to the extent to which inferences can be drawn from the findings.

### Limitations

#### Study 1: ethnography

As mentioned in Chapter 5, there are a number of weaknesses in the methodology adopted for this study. One is the coding of ethnographic descriptions into either a

"naked" or "clothed" category. Not only is this overly simplistic, it introduces a subjective element into the data at its source. With regards to the first weakness, it arises to some extent from problems in defining what is "clothing", as discussed earlier (in the Definitions section). In reality, there can be no perfect definition of such a multi-faceted artefact class, and none will be appropriate in all research domains.

The other issue, the introduction of a subjective element into the coding process, is inevitable. Two measures are taken to minimise its effect. First, an additional category, labeled "ambiguous", is utilised where the descriptions are not readily classified as either "naked" or "clothed", according to the dictionary definition. These data are excluded from the analyses. Second, all the original descriptions and coding decisions (including the "ambiguous" descriptions) are presented, in essentially unedited form, in Appendix A1 (on the accompanying CD), which makes the coding process available for critical scrutiny.

The study has not considered, let alone tested, any alternative explanatory scenarios to the thermal model to account for the evident geographical patterning in the ethnographic data. Neither, for that matter, has it given sufficient consideration to potential confounding variables, such as the likely role of moisture variation (humidity and rainfall) in determining the utility and thermal effectiveness of clothing. This is especially relevant as indigenous garments were manufactured from raw materials (namely animal skins, though bark cloth is documented in a few locations) which are affected more by moisture compared to garments made from woven fibres. Environmental moisture could play a role in the comparative lack of clothes in Holocene Tasmania, as Jones intimated (1971: 522-524), as the wet Tasmanian climate would mitigate against the effectiveness of marsupial skins as protection from cold. This may well constitute a contributing factor, though it is still, strictly speaking, a thermal variable in this context.

Jones also wondered, on this subject, whether high moisture levels in Tasmania would favour the use of body oils and grease as thermal protection in preference to garments. Again, this is not unlikely, but whether it could account for the clothing paradox on its own is a different matter. The study has not examined the issue of body oils and grease in Aboriginal Australia, for reasons relating to the scale of the research, and this does constitute a shortcoming. The subject warrants a systematic analysis, perhaps along the lines of the present clothing study. It would need to established, for example, whether there were significant regional differences in the use of body oils and grease, possibly related to cultural as well as environmental factors, with the latter including climate (especially moisture variables) and the availability of suitable resources. Ethnographically, the use of body oils and grease was widespread, being encountered frequently during the literature survey in the present study, and it is sometimes (though not invariably) recorded on the data sheets, in the "notes" section. The use of body oils or grease is documented as widely as Melville Island in the north (Roe, in King 1827: 240), Port Jackson in the east (e.g. Hunter 1793: 58), and King George Sound in the southwest (King 1827: 128). Nonetheless, there might emerge some regional patterning, for instance between coastal *vs.* inland areas, as well as between northern and southern (or southeastern) zones. In terms of available animal resources, the high animal body fat content that is most useful to humans would tend to be found in colder climatic zones. Whether the use of animal fat and oil as body "covering" by humans was more commonplace in Tasmania compared to the southeastern mainland is not known. It occurred in Tasmania (e.g. Péron 1809: 196), although not as frequently as might be supposed. Most accounts describe only the application of grease and ochre to the scalp, which was not only decorative (red ochre being favoured). It also has thermal implications, with the "coiled" or "peppercorn" scalp hair of the Tasmanians being perhaps better adapted to high rainfall than low temperatures, as discussed below. If, as argued here, the Tasmanians were morphologically more adapted to cold than mainland Aborigines, they would have less need for body greasing, just as they would have less need for clothing. A quantitative analysis would be required to settle this question.

The other main alternative scenario is what may broadly be termed a purely "cultural" explanation for the Tasmanian clothing paradox. This would involve the kind of argument made by Jones (1977a) as to the comparative simplicity (and alleged Holocene contraction) of the Tasmanian cultural repertoire, due primarily to their isolation. This notion of cultural isolation as a problem for the Tasmanians has a long tradition, being invoked for instance by Tylor in his depiction of them as "representatives of palæolithic man" (Tylor 1894: 150). Jones, however, did not emphasize their comparative lack of clothing in his characterisation of their cultural state. Instead, he was inclined to attribute any prehistoric decline in their use of clothing to the onset of warmer climatic conditions in the early Holocene (Jones 1971: 522-524). The debate has since been rekindled, with the Tasmanians' lack of "warmer clothing" being cited specifically as an example of the "maladaptive deterioration" in their cultural and technological attributes that followed the severing of the Bassian land bridge (Henrich 2004: 208-209).

A cultural argument, however, would need to attribute the use of clothing on the mainland to cultural influences, at least in part. As described in the discussion of the results (Chapter 6), the ethnographic evidence makes such a position difficult to defend, as the only likely area where this may be the case is in a few parts of northern Australia, not in southern Australia, where the most clothing was worn. Elsewhere, the pattern on the mainland is consistent with a thermal model. As for other, non-thermal uses of clothing by the Tasmanians, there is evidence that their small capes were used for other purposes as it suited them, for instance as rugs or, in the case of females, for carrying their infants, as was the case on the mainland where

garments were manufactured at all. Henrich maintains that the Tasmanians did not manufacture more substantial garments because such "useful arts" would tend either not to develop, or be lost, or not be sustained, within their isolated culture for purely demographic reasons (ibid). This is implausible for a number of reasons. First, on physiological grounds it is most unlikely that humans will fail to avail themselves of the minimum necessary protection, as this would clearly threaten their immediate survival. Such "warmer" clothes, in other words, were evidently not necessary for thermal reasons among the Tasmanian Aborigines. Neither is there any ethnographic evidence that the Tasmanian Aborigines suffered from exposure, or felt the cold unduly, as surprising as this may have been to white observers. Second, to suppose that the smaller size of the Tasmanian cultural milieu contributed to the clothing paradox presupposes that the existence of a larger cultural milieu contributed to existence of "warmer" garments on the southern mainland. This is possible, but it may be noted that the use of such garments was not ubiquitous, even in those cultural areas where it did occur, such as the Port Phillip / Western Port area (e.g. Faure, in Péron 1809: 269). Whether the observed pattern is more consistent with cultural influences or thermal contingencies, or some combination of the two, is difficult to determine, but the latter would appear the simpler explanation.

One implication of the morphological interpretation of the Tasmanian clothing paradox is that the same effect may be observable on the mainland. That is, Aborigines on the southern mainland might be expected to have developed a degree of morphological adaptation to cold (this question is examined with the Birdsell re-analysis, in Chapters 7 and 8). If this is the case, there may be a reduction in clothing use in the most southerly zone of the mainland. The results of the ethnography study appear to fulfil this prediction, as shown in graphs of clothing in relation to latitude zones (Figures 19 and 20). The trend of increasing reports of clothing with increasing latitude begins to plateau in the most southerly zone, before reversing in the Tasmanian zone. The southernmost mainland zone, between 34°S and Bass Strait, comprises mainly Victoria and southern New South Wales. Such a finding only adds weight to the interpretation of the Tasmanian clothing paradox as reflecting the influence of morphological adaptations.

This pattern highlights the likely importance of interacting effects between biological and cultural adaptations to cold. Not only may this resolve the clothing paradox for Tasmanians, it may have wider application to other questions concerning human responses to changing thermal conditions in prehistory. One such application, it is argued here, involves the intercontinental comparison between late Pleistocene Tasmania and ice age Europe. Specifically, it may have considerable relevance to one of prehistory's enduring enigmas, the rather paradoxical extinction of "cold-adapted" Neanderthals and the ultimate success of tropically-adapted fully modern humans from Africa, at the very time when thermal conditions in late Pleistocene Europe began to deteriorate towards the beginning of very coldest episode, the Last Glacial Maximum. It also involves making inferences as to predictable archaeological signatures associated with the development of clothing for thermal reasons, and particularly the transition from "simple" to "complex" clothing and its technological correlates. The additional studies in this work, on morphology (Chapters 7 and 8) and prehistory (Chapters 9 and 10), raise each of these issues in relation to the Tasmanian situation, and the general discussion to follow will attempt to show how they may have wider ramifications.

**Study 2: morphology**

The thermal re-analysis of Birdsell's morphometric data on Australian Aborigines demonstrates consistent environmental trends on the key indices relating to body shape and limb proportions. The study is not without methodological problems, however, and most of these were discussed earlier. The use of group means will tend to inflate the correlations, though it does not affect the directions of the trends, which generally accord with thermal expectations. Another problem is the skewed distribution of the samples, with the majority on most measures deriving from his "basic" tribal series in the northwest and central western regions. This problem, in contrast to group means, will tend to reduce the strength of any correlations, especially as it leads to a skewed distribution for the matched environmental indices. It makes detecting any environmental associations more difficult, so the finding of significant environmental associations despite this limitation suggests that the overall results may be accepted with some confidence.

With regard to the statistical methods adopted for the Birdsell re-analysis, the use of a separate linear correlation analysis for each morphological variable on each environmental variable has its advantages and disadvantages. It has the virtues of simplicity and ready interpretability, and is a useful strategy for initial exploration of the data in relation to the environmental indices. The major drawback is that with so many analyses (over sixteen hundred in total), the likelihood of statistically significant correlations being false positives (Type I error) – generally considered to lie between one and five percent – becomes a major problem. One strategy to counter this problem is to use a statistical correction technique, such as the Bonferroni correction, which arbitrarily raises the threshold for accepting a correlation as statistically significant. While widely used when a large number of correlation tests are performed, it has not been applied in this study as it does not solve the problem, and introduces a new problem. There is, in fact, no statistical device that can show whether a statistically significant correlation is "real". Making an artificial adjustment to compensate for the number of analyses only distorts the results, and runs the risk of incorrectly removing "real" associations. A more sensible approach is simply to recognise the problem, and to examine the results for consistency of trends across a number of similar variables, accepting that any one

particular significance level may be artefactual. The likelihood of a number of such errors arising by chance in a whole group of similar variables is remote, enabling the results to be interpreted with more confidence. Where an individual significant result exists in isolation, and similar variables fail to reach statistical significance, it should be interpreted with greater caution. In the case of the Birdsell re-analysis, the major groupings of morphological variables that are of most interest in this context, such as relative limb proportions, show consistently significant results.

The factor analyses add little to the correlation findings, other than suggesting that there is major environmental patterning of the morphological data, which is hardly unexpected given the correlation results. More sophisticated multivariate analyses might be productive, as there are indications that some interesting associations may exist between, for example, some of the environmental variables that correspond to combinations of temperature, moisture and sunlight, which may in turn be interpretable as coastal *vs.* inland locations. The morphological data could also be examined for non-linear trends, using for instance quadratic rather than linear functions, and multiple regressions analyses may be useful. The Birdsell data base, in other words, lends itself to further analysis in terms of environmental patterning, although this lies beyond the scale of the present work.

Alternative hypotheses regarding Aboriginal morphological variation include Birdsell's own trihybrid theory, discussed earlier, along with other factors that may exert an influence on the evident geographical patterning. Social factors, and environmental factors other than thermal indices, are likely to be involved, and these might include variables such as dietary and nutritional differences, child-rearing and weaning practices, and activity and lifestyle patterns that may affect the phenotypic development of certain morphological features. If causally or coincidentally associated with climatic indices, such factors could constitute hidden or confounding variables in the analyses. While the potential for such effects is not considered here, the possibility needs to be acknowledged, although it is unlikely that any such effects would occur on all the various morphological attributes that follow predicted thermal trends.

The limitations of the osteological analyses have already been discussed, and the results using Tasmanian data can only be considered suggestive at best. The crural index findings are the more robust, and accord with thermal predictions. The brachial index results (Figure 57) are less reliable, and appear to contradict the thermal prediction of a shorter distal upper limb segment in relation to the proximal segment with colder temperatures in Tasmania. As mentioned in Chapter 8, if valid, this result may nonetheless be accommodated within a thermal model, and may again point to the need to consider interactions between biological and cultural adaptations, as well as past thermal conditions. Specifically, greater use of clothing in late Pleistocene Tasmania would reduce cold exposure (and hence environmental selection pressure) for those parts of the body that are best insulated by the garments. In this case, the type of garments documented ethnographically, which fall very much in the "simple" (as opposed to "complex") category, provide protection only for the upper body and with regard to the limbs, protection only for the upper limbs. Allowing for the development of larger garments in response to colder LGM conditions – and there is archaeological evidence in the form of bone points that may well indicate the sewing together of wallaby pelts to make larger garments, as discussed below – such larger garments will provide at least some protection for the upper limbs while leaving the lower limbs – especially the distal segments – exposed. Only with the use of "complex" garments, which are fitted to cover both upper and lower limbs and may involve the use of additional layers and undergarments, can both upper and lower limbs retain more tropical proportions in cold environments. This is especially relevant in ice age Europe, and for the different adaptive patterns seen among Neanderthals and fully modern humans, but the thermal environment of Tasmania during the LGM was less severe than in the northern hemisphere, requiring only "simple" garments for the Tasmanian Aborigines. Conditions in late Pleistocene Tasmania were comparable to the earlier part of the last ice age in Europe, and would demand the type of garment that affords some protection for the upper limbs, allowing the Tasmanians to retain more "tropical" proportions for the upper, but not the lower, limbs.

There are some problems for this interpretation of the Tasmanian brachial index results. Neanderthals, who may have used similar "simple" garments in ice age Europe, have low brachial indices. This may reflect a late adoption of such protection, or a lack of any clothes, as some have suggested, although the latter is most unlikely given the thermal conditions. The former is more likely, and it is relevant to note that Neanderthals and their immediate ancestors endured not one but two ice ages in Europe.

As mentioned in Chapter 7, morphological cold adaptations may also be relevant to the question of late Pleistocene "robusticity" in the Australian population. The results for the crural index suggest a thermal rather than an "archaic" influence, although only data for Willandra Lakes are utilised in this analysis. The subject would benefit from a more comprehensive study utilising a more extensive Australian sample, and could include other osteological measures such as cranial data.

**Study 3: prehistory**

This study involves a preliminary examination of human behavioural responses to thermal conditions that approached the physiological limit of cold tolerance. It also demonstrates how these principles can be applied to a particular archaeological problem, in this case the "southwest surprise". This relates to the unanticipated presence of human occupation sites in the higher altitude southwest

area during the last ice age, and to the "apparent paradox" that Tasmanian post-glacial sites are found almost exclusively outside the southwest, whereas all the known southwest sites are of late Pleistocene age (Allen and Cosgrove 1996a: 3).

The archaeological data in the study comprise published dates for late Quaternary occupation sites in Tasmania, together with site aspect (the direction faced by the cave or rock shelter opening) where available. There is no discussion in this study as to any dating issues for individual sites, and the quoted dates and ranges are those given in the original reports. For the half dozen assigned loosely to the "late" or "terminal" Pleistocene, each of these have been allocated to one of six millennial intervals following the LGM, to allow for a likely range of uncertainty and to avoid creating an artificial peak of site frequency within any one late Pleistocene millennium for the statistical analyses. The use of millennia as the time unit has its drawbacks, but represents a reasonable compromise between the scale of resolution allowed by the dating methods and the need for a sufficiently sensitive data base for analysis in relation to temporal and thermal indices. The latter derive from a "template" of available palaeoenvironmental estimates at each millennial interval for mean temperatures, wind velocities and relative humidity levels between 35,000 and 1,000 years before present. These are applied to meteorological data from the Bureau of Meteorology at four weather stations in Tasmania. These locations provide an indication of regional variation in thermal conditions, although they represent only a crude approximation. Emphasis is given to the contrast in average wind chill estimates between Strathgordon, in the comparatively protected southwest, and Low Head on the more exposed northern coast. The wind chill estimates are calculated from average monthly (January and July) temperature and wind speeds, which, as discussed in Chapter 9, are not true average wind chill and will underestimate the likely wide variation in actual levels.

As discussed in Chapter 9, the late Pleistocene wind chill estimates used in the analyses derive from Bowden's (1983) study of coastal dunes in northeastern Tasmania. He had concluded that average LGM wind speeds were 8-10 km/hr higher than at present, and it was also noted that, in Colhoun's opinion, average wind speeds may well have been higher than this figure. On the other hand, one study has questioned whether LGM wind speeds in the region were any higher than those of the present. This latter study examined aeolian dust sediments in deep-sea cores from the Tasman Sea, and it attributed the increase in transported dust from southeastern Sahul largely to greater aridity and loss of vegetation cover, rather than to stronger winds during the LGM (Hesse and McTainsh 1999: 347). The core samples, though, cover only the post-LGM period from 20 to 0 ka, during which there is a steady decline in the proportion of the coarser-grained dust particles that are the best proxy of wind strength (ibid: 346). In making interpretations of patterns of dust deposition during the ice ages, it can be difficult to distinguish between the relative contributions of higher wind speeds and greater dust availability (due mainly to aridity and reduced vegetation cover). An analysis of Tasman Sea cores spanning the last few glacial cycles suggests that a combination of stronger winds and greater aridity is likely, and "it seems reasonable to accept that, in general, glacial periods were probably marked by stronger winds over much of Australia" (Hesse 1994: 269). Other proxy indicators of wind speed, such as oceanic upwelling and fluctuations in glacial mass, point to intensified westerly airflows and, while none of the proxy indicators are without their problems, "in combination, the records are convincing for a period of enhanced westerly flow at the LGM" (Shulmeister *et al.* 2004: 43). Clear evidence for an increase in absolute wind speed is, however, "much less convincing" and "the frequent assertions in the literature of higher wind speeds at the LGM... need to be tempered until accurate proxy records of wind speed become available" (ibid: 46). It needs to be appreciated, though, that even present-day average wind speeds are generally high (by Australian standards) in Tasmania, particularly in the coastal areas. At Low Head on the northern coast for example, mean annual 9am wind speed is 19.7 km/hr and mean July 9am wind speed is 21.0 km/hr (Table 24).

Wind speed is one of the two main components in wind chill: the other is air temperature. Even assuming present-day wind speeds for the LGM, the lower air temperatures alone will translate into a greater wind chill effect for humans in late Pleistocene Tasmania. Another aspect of wind chill, mentioned in Chapter 9, is the effect of varying atmospheric moisture levels, of which relative humidity is the most widely used measure. The palaeoenvironmental estimates for late Pleistocene Tasmania (Table 26) have incorporated an adjustment for the likely lower humidity levels associated with glacial aridity. The adjustment reflects the standard view that lower relative humidity exacerbates wind chill. To take account of this, the wind chill figures are lowered by -1°C with relative humidity reduced from a present-day 70% to 50% (between 30 and 24 ka and between 16 and 13 ka), and by -2°C with a relative humidity of 30% (for the period between 23 and 17 ka). However, an opposing view is that wind chill increases with increasing relative humidity at air temperatures over 10°C, and the effect of varying relative humidity at air temperatures <10°C is negligible (Steadman, pers. comm.). For late Pleistocene Tasmania, this would mean that there was no additional cooling effect on humans due to the drier LGM conditions.

If both these scenarios are accepted – that LGM wind speeds were no higher than at present and there was no additional cooling effect of lower relative humidity – then the wind chill estimates in Table 26 and some of the subsequent analyses shown in Chapter 10 would need to be revised. With these two factors removed, the palaeoenvironmental data for the four locations would appear as in Table 27 (part b), using the 20 ka millennium as broadly

| ka | --- TEMPLATE --- | | | Hobart | | Oatlands | | Low Head | | Strathgordon | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | temp△ [°C][1] | wind△ [km/hr][2] | hum△ [rel.%] (effect)[3] | Jan WC[4,5] 9am/3pm | Jul WC 9am/3pm | Jan WC 9am/3pm | Jul WC 9am/3pm | Jan WC 9am/3pm | Jul WC 9am/3pm | Jan WC 9am/3pm | Jul WC 9am/3pm |
| *a) With stronger winds and humidity effect (as per Table 27, p. 174):* | | | | | | | | | | | |
| 20 | -6.5 | +9.2 | 30 (-2) | 3 / 6 | **-7** / -3 | 2 / 7 | **-8** / -5 | 2 / 4 | **-8** / -3 | 4 / 9 | -2 / 1 |
| *b) Without stronger winds or humidity effect:* | | | | | | | | | | | |
| 20 | -6.5 | 0.0 | 70 (0) | 8 / 10 | -2 / 2 | 6 / 11 | -3 / -1 | 6 / 8 | -3 / 0 | 6 / 11 | -2 / 1 |
| *c) as for b), with LGM mean temperature reduction of 8°C:* | | | | | | | | | | | |
| 20 | -8.0 | 0.0 | 70 (0) | 6 / 8 | -3 / 0 | 5 / 10 | **-5** / 2 | 5 / 7 | **-5** / -2 | 4 / 9 | -4 / -1 |

*Notes:* 1-5 as per Table 27, page 174

Table 27 LGM wind chill estimates using late Holocene wind speeds

representative for the LGM. Also shown are results if the recent estimates for Sahul of a mean LGM temperature reduction around 8°C were applicable in late Pleistocene Tasmania (part c).

While the wind chill estimates with present-day wind speeds result in weaker LGM contrasts between the southwest and other regions of Tasmania, the former remains somewhat milder despite the lower air temperatures. Moreover, on the present-day northern coast (Low Head data), mean July 9am wind chill estimates approach the “critical” -5°C level, especially if temperatures fell by more than the 6.5°C estimate. Actual conditions would have varied around these mean figures, and lower temperatures (along with stronger winds) would have occurred at times. For example, the lowest recorded July temperature at Low Head (where the meteorological records span 124 years) is -2.8°C, which would equate to -9.3°C with an LGM temperature reduction of 6.5°C, and with even a modest wind speed of 10 km/hr, this produces a wind chill level of -11°C. An increase in LGM wind speeds, in other words, is not needed to produce average wind chill estimates approaching the critical -5°C level for late Pleistocene Tasmania. More important, the palaeoenvironmental estimates are based on annual and monthly averages, which will under-estimate thermal stresses for humans when conditions (either air temperatures, or wind velocities, or both) were more extreme than the average figures.

When the thermal trends in cave / shelter site numbers are re-examined using these more conservative estimates of the wind chill levels (*i.e.* present-day average wind speeds and a negligible added cooling effect of the drier conditions), the trends shown in Figure 68 are found, extrapolating from the July 9am meteorological data for Strathgordon.

Correlation results are shown in Figure 69. For the 35 - 0 ka period, the Pearson correlation coefficient is -.785, significant at the 0.05 level (1-tailed) despite the low number of wind chill categories when using winter estimates (January 9am data were used in the prehistory study). For the post-LGM period, the correlation is -.890, significant at the 0.01 level. For the period leading into and including the LGM, the correlation is a near-perfect -.998, significant at the 0.01 level.

An alternative explanatory scheme for the “southwest surprise” would focus on the ecological issues highlighted by Cosgrove. He has shown how targeting of marsupial species, especially the Bennett’s wallaby, provided humans with a reliable resource base that could be readily exploited in winter, when lower temperatures exacerbated the reduced availability and predictability of resources due to glacial aridity, which pertained throughout the Tasmanian (including the Bassian) region. The two schemes (thermal and ecological) are not mutually exclusive, and some aspects of Cosgrove’s “ecological tethering” model have thermal implications. These include the targeting of marsupials to provide the raw materials for clothing and for the increased caloric returns needed to maintain higher basal metabolic rates in the colder conditions, as discussed below. Also, exploitation of faunal resources that were localised to discreet patches of grassland would reduce the

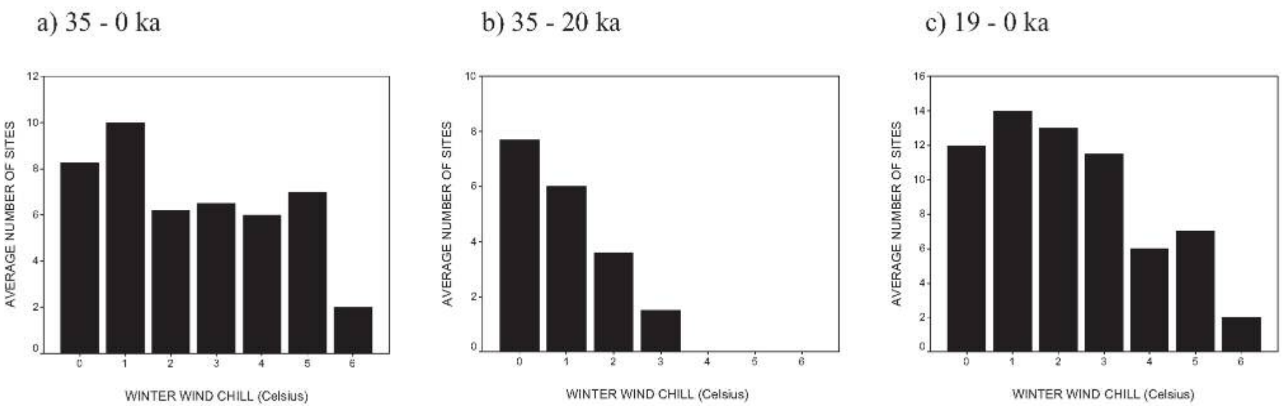



Figure 68 Average site numbers per wind chill category (revised)

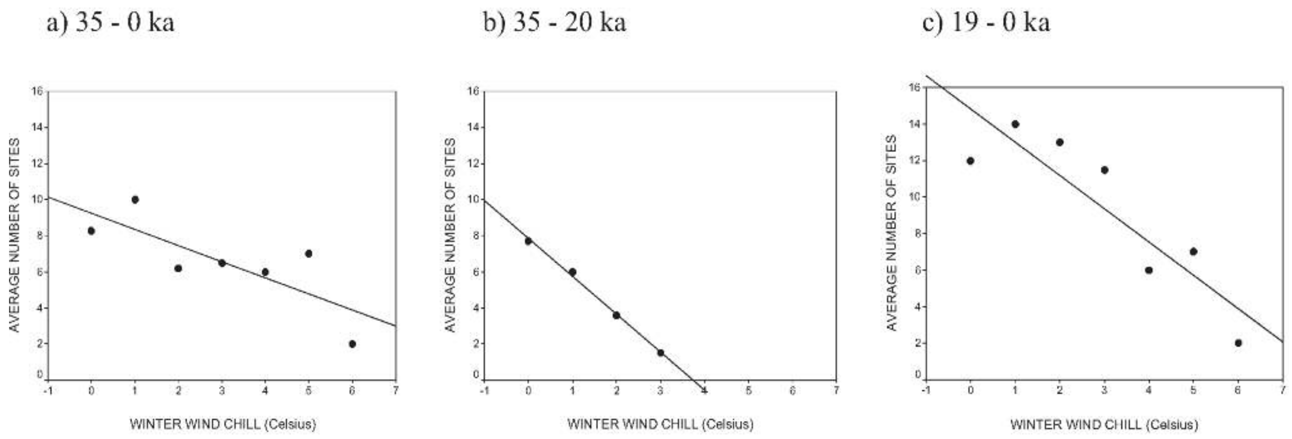



Figure 69  Correlations: average site numbers *vs.* (revised) wind chill estimates

exposure risks for humans, who could therefore travel relatively shorter distances from, and hence spend less time outside, their sheltered occupation sites in hunting these ecologically "tethered" marsupials.

The correlations between site utilisation and thermal indices may reflect the influence of such intervening or "hidden" variables, rather than being entirely direct associations. Cosgrove, for instance, attributes the dramatic decline in site utilisation at the end of the ice age mainly to the rapid encroachment of dense forests. The consequent reduction in wallaby populations rendered the southwest region less useful to humans, compared to the expanding resource options that became available elsewhere in Tasmania at the time. This is quite plausible in itself, although the thermal model would point out that human hunter-gatherer groups (including, ethnographically, the Tasmanian Aborigines) generally avoid entering caves, and the primary reason for a human presence in this otherwise inhospitable landscape – *i.e.* the availability of protection from dangerous wind chill levels – simply became less relevant after the ice age.

Cosgrove and his colleagues at La Trobe University have made available (on CD-ROM) an extensive archaeological data base on southwest Tasmania (McWilliams *et al.* 1996). This contains a massive quantity of data on frequencies of lithic material and faunal remains, spit by spit, square by square, using 7mm and 3mm sieves, from the eight sites excavated as part of the Southern Forests Archaeological Project (SFAP) between 1987 and 1992. Some of these data (e.g. frequencies of certain classes of stone tools and fauna) are of interest in terms of the possible archaeological correlates of clothing manufacture, and could be analysed in relation to thermal indices. However, such an undertaking is beyond the scale of this study, which constitutes a deficiency given the desirability of exploring this issue in the present context.

There are certain problems and limitations in attempting a thermal analysis of the SFAP data base. The most obvious is the likely intercorrelation between the various archaeological variables (such as tool and faunal frequencies) and site utilisation, which means that similar correlations with thermal indices can be expected to those found for site utilisation (e.g. Figures 64 and 65). For example, at Bone Cave (elevation 400m, aspect 335°), where there are two occupation periods (29-23,000 BP and 17-14,000 BP), the frequencies of flaked stone artefacts correlate with mean minimum winter temperature estimates (extrapolating from the Strathgordon meteorological data), with $r$ = -.772 (Figure 70). Faunal data show similar patterns when examined in relation to mean winter minimum temperature estimates. The latter for instance correlates with wallaby at Warreen Cave, where the NISP correlation coefficient is $r$ = -.732, and the mean weight correlation, $r$ = -.789.

The site aspect findings in Chapter 10 are suggestive of a wind chill effect in the selection of cave sites for human occupation during the late Pleistocene, showing a distinct paucity of cave and rock shelter locations exposed to the colder southwesterly winds. As mentioned in the discussion of those findings, a comparison with shelter sites across the wider Sahul region during the late Pleistocene would be useful. While the scale of the present study does not allow a full exploration of this issue, a preliminary survey of such

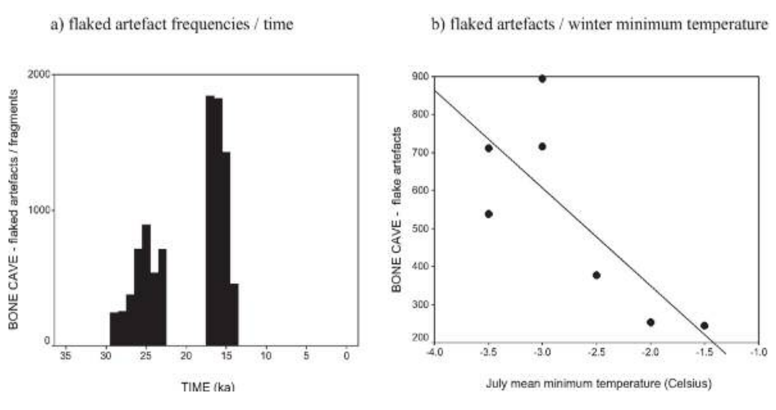



Figure 70  Bone Cave: flaked artefact frequencies

| site | latitude (°S) | dates (ka) (range) | elevation (metres) | aspect (compass°) | references |
|---|---|---|---|---|---|
| 1 Carpenter's Gap | 17° | 43 - 23 | | 030° | O'Connor & Fankhauser 2001: 288 |
| 2 Nurrabullgin Cave | 17° | 37 - 0 | | 143° | David 1993: 51 |
| 3 Mandu Mandu | 22° | 32 - 20 | 60 | 290° | Morse 1988: 82 |
| 4 Devil's Lair 34° | 31 - | 17 | | 020° | Dortch 1984: 17 |
| 5 Colless Creek | 19° | 30 - 0 | | 080° | Hiscock 1984: 124 |
| 6 Fern Cave | 17° | 29 - 17 | | 030° | David 1991: 43 |
| 7 Koolan 2 | 16° | 27 - 25 | 40 | 320° | O'Connor 1989: 96 |
| 8 Puritjarra | 23° | 27 - ? | | 110° | Smith 1989: 96 |
| 9 Nombe | 6° | 26 - 0 | 1660 | 080° | White 1972: 128 |
| 10 Malangangerr | 12° | 25 - 18 | 150 | 195° | Schrire 1982: 76 |
| 11 Serpent's Glen | 25° | 24 - 1 | | 175° | O'Connor et al 1998: 14 |
| 12 Nawamoyn | 12° | 22 - 1 | 150 | 325° | Schrire 1982: 110 |
| 13 Koonalda Cave | 31° | 22 - 15 | 100 | 135° | Wright 1971: 22-23 |
| 14 Birrigai (E) | 35° | 21 - 0 | 730 | 135° | Flood et al 1987: 10 |
| 15 Birrigai (W) | 35° | 21 - 0 | 730 | 310° | Flood et al 1987: 10 |
| 16 Burrill Lake | 35° | 21 - 0 | | 060° | Lampert 1971: 6 |
| 17 New Guinea II | 37° | 21 - 1 | 700 | 105° | Ossa et al 1995: 26 |
| 18 Allen's Cave | 31° | 20 - 2 | 100 | 350° | Marun 1972: Fig. 20 |
| 19 Kenniff Cave | 25° | 19 - 10 | 760 | 355° | Mulvaney & Joyce 1965: 156 |
| 20 Cloggs Cave | 38° | 18 - 9 | 76 | 320° | Flood 1974: 176 |
| 21 Miriwun | 16° | 18 - 12 | | 325° | Dortch 1977: 112 |
| 22 Seton | 36° | 16 - 11 | 60 | 030° | Lampert 1971: 99 |
| 23 Early Man | 15° | 15 - 0 | 170 | 250° | Rosenfeld et al 1981: 6 |
| 24 Noola | 33° | 13 - 8 | | 120° | Tindale 1961: 193-194 |
| 25 Lyre Bird Dell | 34° | 13 - ? | 305 | 255° | Stockton & Holland 1974: 41 |
| 26 Bridgewater South | 38° | 12 - 8 | | 280° | Head 1985: 3 |
| 27 Jimeri 1 | 12° | 11 - ? | 250 | 190° | Schrire 1982: 147 |

Table 28 Archaeological data – Sahul

sites shows a similar pattern to that of Tasmania, but with a somewhat less pronounced trend for a lack of sites facing into the southwest quarter. The data are shown in Table 28, and the results in Figure 71. The number of sites included is restricted to those with Pleistocene dates and is not comprehensive. The findings nonetheless may indicate that protection from wind chill was a significant but possibly less critical issue for humans in late Pleistocene Sahul, north of the Tasmanian area. An adequate analysis would also need to take into account the local thermal conditions at the various locations, especially prevailing wind speeds and directions.

In focusing on the evidence for behavioural adaptations, and in highlighting how winter wind chill averaged around the critical -5°C mark in exposed areas, the prehistory study draws attention to the likely need for clothing in late Pleistocene Tasmania. While it is not possible to quantify the benefits of any morphological adaptations, these are unlikely to have been sufficient for naked humans in winter, especially in an Aboriginal population whose ancestral heritage derived from subtropical environments. Even with access to shelter in the southwest, humans still needed to safely move around the landscape for hours at a time. They needed portable protection to survive, and this would have entailed the development of adequate clothing.

The archaeological evidence that bears upon this issue is considered below. It underlines the need to consider biological and cultural cold adaptations not in isolation, but as parallel and often interacting responses. Insofar as the evidence may point to the use of clothing, and even to the use of more substantial clothing than documented ethnographically for the late Holocene, reasons for a reduction in clothing during the Holocene will have a bearing on the as indicated by palaeoenvironmental and physiological as indicated by palaeoenvironmental and physiological evidence. There would be no cultural disincentive for its subsequent abandonment (especially given an early "climatic optimum" around 8-9,000 years ago), as only "complex" clothes are prone to acquire non-thermal cultural uses that act as promotors for their continuing use regardless of thermal conditions.

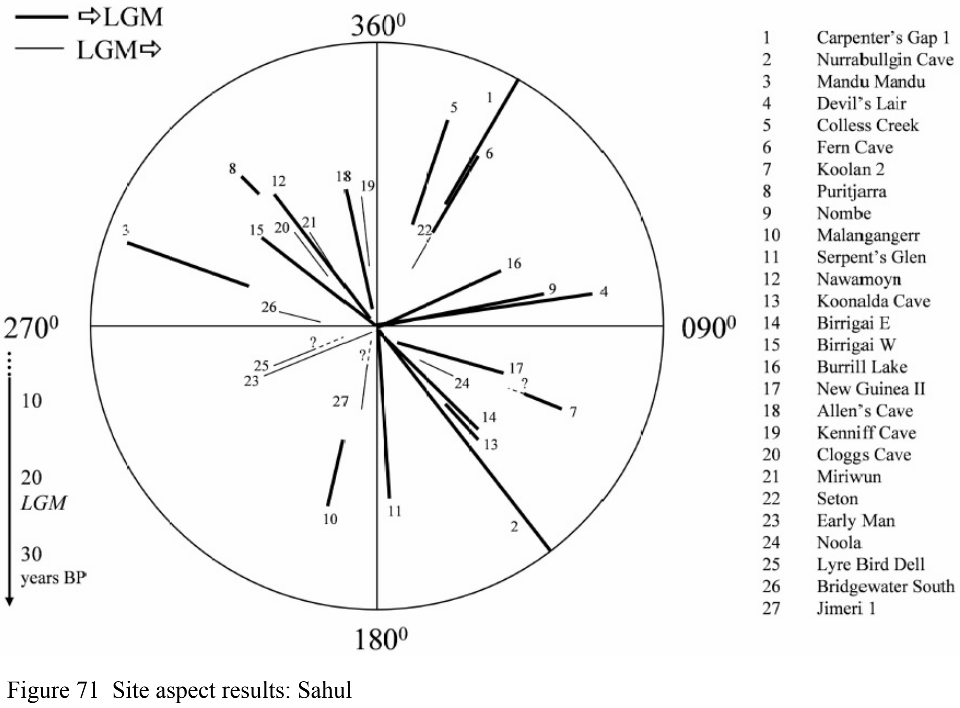



Figure 71 Site aspect results: Sahul

# Chapter 12  Further Issues

It has been intimated from the outset that the Tasmanian clothing paradox, and its resolution, may have wider ramifications. These are many, and those to be addressed in the following discussion are as follows:

*Ethnography*: is the Tasmanian paradox unique, or may there be comparable instances in other societies?

*Morphology*: besides body and limb proportions, might some other physical features of the Tasmanian Aborigines be environmental adaptations?

*Prehistory*: first, what is the archaeological evidence for other behavioural adaptations in late Pleistocene Tasmania, especially clothing? Second, to what extent can Tasmania be compared to ice age Europe in terms of human behavioural responses and their archaeological signatures?

## Ethnography: Tierra del Fuego – another paradox?

While the archaeological record of late Pleistocene Tasmania invites an intercontinental comparison with ice age Europe, the ethnographic record invites comparison with the southernmost area on the continent of South America., especially Tierra del Fuego. Not only does the latter share a thermal environment that is broadly similar in many respects to that of Tasmania, its indigenous inhabitants prior to white settlement used surprisingly little clothing. Moreover, there is some evidence that they used less clothing than did their neighbours to the north, the Tehuelche of Patagonia. In April 1765, Byron observed of the Fuegans:

> *...and notwithstanding the weather is piercing cold they were all naked except a Scrap of Seals Skin they had over their Shoulders*
>
> (Byron, in Gallagher 1964: 80)

The Patagonians, on the other hand, were typically clad from head to foot, and also used small undergarments, as described by Fitz-Roy during his first voyage to the region late in 1826:

> *They were all wrapped in mantles, made chiefly of the skins of guanacoes, sewed together with the sinews of the same animal. These mantles were large enough to cover the whole body... Under their mantle the women wear a sort of petticoat, and the men a triangular piece of hide instead of breeches*
>
> (Fitz-Roy 1839, I: 17-19)

Among the indigenous peoples of Tierra del Fuego, the tribal groups known as the Ona inhabited the drier open plains of the north and east, and wore garments not dissimilar to those of the Patagonians (Lothrup 1928: 52-53). It was Yahgan people, inhabiting the heavily forested, more mountainous island chain to the immediate south of Beagle Channel, and to some extent, those of the Alaculef tribes in the west, who were comparatively naked (Cooper 1917: 193-194). The Yahgans were described as follows by Lothrup on his visit in the summer of 1924-25:

> *It is no exaggeration or overstatement to remark that, considering the climate in which they live, this southernmost tribe had less body-covering than any other people in the world. As compared to the Ona, their garments, similar in nature, were deficient in size... We must add that individuals of both sexes and all ages often went entirely naked... The usual cape worn in summer and winter alike by both men and women was a seal or sea-otter skin. Sometimes two or more were sewn together. In general, however, this garment extended only to the waist and did not completely circle the body*
>
> (Lothrup 1928: 121-123)

The difference in clothing between the Yahgans and their neighbours to the north presents some striking similarities to the Tasmanian clothing paradox. There are, nevertheless, some important differences to be noted. First, the "paradox" is less distinct in Tierra del Fuego than in the Australian case. Second, with regard to morphological adaptations, all the New World populations are relatively cold adapted (e.g. Roberts 1978: 22-29), attributable to most if not all of the ancestral groups migrating from northeastern Asia across the Bering Strait region during the late Pleistocene (e.g. Merriwether *et al.* 1996). In contrast, the Australian Aboriginal population is distinctly tropical in terms of thermal morphological adaptations.

As to possible factors that might account for a Fuegan clothing paradox, the argument presented earlier in relation to the Tasmanian clothing paradox would suggest that morphological differences should be considered. The present study does not allow a full treatment of the Fuegan data, though it may be noted that the Yahgan (and the Alaculef) were markedly shorter in stature than the Ona. As Hooton pointed out in his discussion of the meagre (mainly craniometric) data at his disposal (in Lothrup 1928: 41-47), the Yahgans were comparatively short-legged, which may be consistent with their being more cold-adapted, at least with regard to Allen's Rule. It can be noted that archaeological evidence for humans in southern South America dates only from around 11 ka (Borrero and McEwan 1997), meaning they are unlikely to have occupied their environment for as long as Aborigines are known to have been present in Tasmania, giving the Tasmanians a longer period in which to become adapted to local conditions.

Another possible factor is the role of differences between the environments occupied by the Yahgans and Alaculef in the south and west on the one hand, and the Ona in the north and east on the other. Thermally, there are some important differences between these two areas, despite their geographical proximity. That of the Ona was compar-

atively exposed, in terms of both topography and vegetation cover, and was also drier. The physical environment of the Yahgan, however, was more rugged, with dense forests, and with higher moisture levels (both rainfall and relative humidity). All these factors have been cited earlier as relevant to the Tasmanian situation, both in terms of the natural shelter afforded by rugged topography in the south-west during the late Pleistocene, and that afforded by the return of forest cover during the Holocene, along with the role of high moisture levels making clothing less effective. Environmentally, the Yahgans benefitted from having access to more natural shelter from wind chill, and their wetter environment may have rendered heavy clothing a less practical option. They also applied animal oils and grease to their bodies (Fitz-Roy 1839, II: 139).

The ethnographic existence of a comparable clothing paradox in a similar environmental context on another continent, and the possibility that similar morphological and environmental factors may be involved, adds credence to the interpretation of the Tasmanian clothing paradox outlined above. Comparisons between the Fuegans and the Tasmanians have been made by many observers over the years, and recently by Henrich (2004). The latter's interpretation, discussed earlier in relation to cultural explanations for the paradox, attributes considerable import to the Tasmanians' apparent lack of sufficiently warm clothing compared to the Fuegans, being cited as key evidence as to their alleged "deterioration".

In mounting his case for the Tasmanians' "maladaptive losses", Henrich overlooks a few important aspects. He mentions, in passing, the Ona and the Yahgan tribal groups, but thereafter refers to them collectively as "Fuegans", with his descriptions of their clothing relating to the Ona. Were he to compare Tasmanians to the Yahgan, he might conclude the latter were more "maladapted", given their colder environment. This would not fit his model, with Fuegans supposedly benefitting from being less isolated than the Tasmanians. Even accepting his loose ethnography, his argument with respect to clothing does not stand scrutiny. While mentioning that the latitude of Tierra del Fuego lies a further 10° south of Tasmania, and that the Fuegan environment is therefore "harsher (i.e., colder)", he fails to draw the obvious conclusion that this simple difference in thermal conditions might contribute to the Fuegans, on average, wearing somewhat warmer clothes.

## Morphology: other adaptive Tasmanian features

Besides adaptive trends in body shape and limb proportions among the Tasmanian Aborigines, for which the ethnographic and osteological evidence is suggestive but far from conclusive, other distinctive Tasmanian physical features may reflect environmental adaptations. The existence of other physical adaptations would add to the case for their possessing biological cold adaptations, which in turn would be consistent with their needing less clothes than mainland Aborigines in their Holocene environment.

Among the relevant features are skin colour, body hair, scalp hair, head shape and nasal structure. The Tasmanians are said to have differed to some extent from the mainland Aborigines on most of these physical variables and, as seen in the Birdsell re-analysis in Chapter 8, the mainland Aborigines manifest clinal variation with environmental indices on these morphological variables (e.g. body hair and skin colour). Each of these features warrants a brief discussion in relation to the Tasmanian Aborigines.

1. *Skin colour* shows a marked variation with latitude for most human groups (e.g. Coon 1965: 229-235, 1982: 48-59), with more deeply-pigmented skin predominating in lower latitudes. This applies to the mainland Australian Aborigines (Birdsell 1949: 110, Kirk 1983: 90). Exposure to solar radiation is considered the main selective agent, with dark skin protecting against solar skin damage in the tropics, and light skin protecting against deficiency of vitamin D in higher latitudes; habitual use of clothing is another factor (Abbie 1969: 29, Weiner 1971: 139-140, Harrison 1975: 187, Jablonski and Chaplin 2003: 78-79). The daily influx of ultraviolet radiation is inadequate for vitamin D synthesis when the sun fails to reach 20˚ above the horizon for more than a month or two. The critical latitude at which this occurs in winter is around 40˚ north and south of the equator (Coon 1965: 232, Jablonski and Chaplin 2003: 77), which is the case for Tasmania. While there may have been considerable individual variation, the Tasmanian Aborigines' skin is often described as somewhat lighter than that of the mainland Aborigines, ranging from black to a reddish-brown or coppery hue (Roth 1899: 12-13, Plomley 1977: 9).

2. *Body hair* correlates positively with latitude within the major human groups, and the results in Chapter 8 show similar trends among mainland Aborigines. Abbie, however, disputed the trend to greater body hair in the south-east, although his own data (including photographs) appear to contradict his interpretation (Abbie and Muecke 1971: 116-119). No such data exist for the Tasmanian Aborigines, nor are photographs useful in this regard, as they are usually clad in European-style garments. Some of the accounts by visitors prior to 1803 describe at least some of the males and children as having body hair, though none were considered particularly hirsute (LaBillardière 1800: 311, Roth 1899: 12, Plomley 1983: 163). Plomley is typically circumspect: "Very little is known concerning the amount and distribution of hair on the trunk and limbs" (ibid). High moisture levels (humidity and rainfall) in Tasmania may be expected to reduce the thermal trend towards greater body hair, as seen in the results of the Birdsell re-analysis, where the mainland data show a negative correlation between quantity of body hair (and beard growth) and both the temperature and the moisture variables. The Tasmanians, in this case, would have somewhat less body hair than

might otherwise be expected given the air temperatures, and this could be attributable to higher environmental moisture levels.

3. *Scalp hair* among the Tasmanians is described variously as "woolly", "frizzy", "tightly coiled", and "spiral" in form, whereas scalp hair among the mainland Aborigines was characterised as either straight or at most "wavy" in form (e.g. Huxley 1870: 404). Curly hair may be advantageous in humid conditions (Coon 1965: 175), and tightly coiled hair may offer an advantage in more enclosed environments with high precipitation, whether hot or cold. Where evaporation of perspiration from the scalp is less of an issue (either because of low temperatures where sweating is less copious, or in hot humid environments where it is less effective for cooling), but where high rainfall makes dampness a problem, tightly coiled hair could help to reduce penetration of moisture to the surface of the scalp.

4. *Head shape*, being a cranial feature, is one of the most well-studied of human features in physical anthropology. On a global scale, a more rounded head shape (*i.e.* a high cephalic index) is associated with colder environments (Beals 1972, Steegmann 1975: 138). Mainland Aborigines have a markedly elongated (or dolichocephalic) head shape (Coon 1965: 174, Abbie 1969: 37), consistent with their tropical (or linear) body form. Tasmanian head form, in contrast, is described as more rounded (Kirk 1983: 95), which is not unexpected in a higher latitude population. Birdsell remarks of the Australian cephalic index data that "with the exception of Tasmania, all of its inhabitants could be called long headed" (Birdsell 1993: 383).

5. *Nasal structure* varies in relation to thermal environment, with both temperature and humidity being important (Thomson and Buxton 1923: 115-11, Steegmann 1975). The human nose tends to be wider in both warmer and more humid environments, and this raises the question of what happens to nose shape in cold but humid climates like that of Tasmania. The answer appears to be that humidity takes precedence over temperature, with the nasal index correlating more highly with humidity than with temperature (Weiner 1954). The nasal index for Australian Aborigines is high by global standards, and the clinal topography of the index for mainland Aborigines conforms to these predictions (Birdsell 1993: 411-413). The Tasmanian Aborigines were considered distinctive in having "a broad nose with prominent nostrils" (Plomley 1983: 162). This can be attributable to higher environmental humidity compared to the adjacent mainland, and as such the Tasmanian Aborigines would corroborate Weiner's findings in relation to humidity, temperature and nasal form based on data from other human groups.

It is difficult to identify Tasmanian physical features that may not be environmental adaptations. Morphological adaptation to local (and past) environmental conditions appears to have influenced the development of their distinctive physical features, leading to modification of Aboriginal morphology over a period of some 35,000 years. The existence of a constellation of environmentally-adaptive morphological features adds weight to the argument that biological adaptations, together with other environmental considerations such as high moisture levels (reducing the thermal effectiveness of clothing), need to be considered as factors that may, in large measure, be responsible for the Tasmanian clothing paradox.

## Prehistory

The prehistory study (Chapters 9 and 19) examined archaeological evidence for one prehistoric behavioural pattern in Tasmania that may reflect the direct influence of thermal factors, namely use of natural shelter in the southwest as protection from physiologically-critical wind chill levels. The main area of interest in the present context, however, is evidence for the use of clothing by Tasmanian Aborigines, especially whether this behaviour was more pronounced during the last ice age. The results, particularly the palaeoenvironmental reconstruction, would suggest that wind chill levels demanded greater portable protection, and a thermal model predicts that the archaeological record will yield evidence of this behavioural response.

In the discussion to follow, features of the late Pleistocene archaeological record are reviewed which may represent signatures of the use of clothing, and of related thermal considerations. These features are among those that would need to be addressed in making intercontinental comparisons between Tasmania and other regions where prehistoric humans confronted major environmental changes, changes that resulted in altered thermal conditions which may have approached or exceeded the physiological limits of human cold tolerance.

### Bone tools

Bone points were first recovered from a number of early to mid-Holocene archaeological sites in Tasmania, including Jones' Rocky Cape excavations in the northwest of the island. Jones was able to relate the existence of these tools to the use of clothing by Aborigines in the ethnographic present, and also to similar archaeological finds dating to the late Pleistocene and early Holocene at other locations in the wider Sahul region (Jones 1973: 280). Bone points were subsequently recovered from the late Pleistocene cave sites in southwest Tasmania, and again Jones related their presence to the manufacture of clothing. In this instance, he alluded more specifically to the likely concurrence between their appearance in the archaeological record and human physiological requirements for survival in late Pleistocene thermal environments. He also discussed the ethnographic evidence for reduced clothing use among Tasmanian Aborigines in the late Holocene, compared with their likely clothing requirements during the last ice age. This led him to infer a causal connection between reduced clothing use and the disappearance of bone tools from the archaeological

record of the island (Jones 1990: 283-284). Given the finding of a single bone point dating to no more than 3000 years ago at Louisa Bay on the southern coast (Vanderwal 1978: 110-112), the disappearance of bone tools can be dated to somewhat more recent than the mid-Holocene.

In his thesis on the Rocky Cape excavations, completed more than a decade prior his involvement with the ice age Tasmanian sites, Jones had discussed the hypothesised relationship between these tool forms and clothing in some detail. He did so in the context of examining the "problem" of the Tasmanian Aborigines discarding some of their pre-existing technologies during the Holocene. As mentioned earlier, he was inclined to attribute this ultimately to their physical and cultural isolation from the mainland after sea levels rose at the end of the last ice age (Jones 1977a). In relation to clothing, however, Jones was more inclined to attribute any post-glacial reduction to thermal rather than cultural or demographic factors. He mentions one of these factors, relating to the wetter conditions in Tasmania during the Holocene, and he also makes the same interesting intercontinental comparison that was discussed above:

> *Tasmania is wet rather than cold, especially on the coast where most of the Aborigines lived. Such conditions may not favour heavy skin clothing, which becomes sodden, stiff and difficult to dry. Perhaps the best protection from this weather is to smear one's body with a paste of animal fat and ochre. This keeps the heat within the body; the water rolls off outside, and the surface quickly dries in a light breeze. Tasmania, with its abundance of seals and mutton birds for oils, and its rich sources of ochre, was better endowed in these respects than was the mainland. An interesting analogy is offered by the natives of Tierra del Fuego and the adjacent mainland of South America. On the cold, dry southern pampas and the plains of eastern Tierra del Fuego, the Ona and allied people had large skin cloaks made from guanaco fur, looking similar to the Victorian Aborigines. The Yaghans and Alacaluf of the wet western archipelago were generally naked and anointed [sic] their bodies with seal fat and ochre as did the Tasmanians(Lothrup 1928)*
>
> (Jones 1977a: 523).

Bowdler criticised the emphasis given by Jones (and others such as Mulvaney and Flood, e.g. Mulvaney 1975: 99-100) to the use of bone points for making garments. Instead, she linked the disappearance of bone tools in the Holocene to cessation of fishing, and argued for their primary function being as netting needles (Bowdler 1984: 126). A use-wear analysis of nineteen bone points, nine of which were classed as "fine points", from two of the cave sites (Bone Cave and M86/2), showed evidence for the piercing of dry skin, as well as some evidence for their use as spearpoints (Webb and Allen 1990: 77-78). Ethnographically, the wooden spears used in Tasmania were not tipped, and the need for tipped spears is unclear. Tasmanian Aborigines used wooden clubs or waddies to throw at prey animals, and were adept at throwing large stones "accurately and with force", as early European visitors discovered (Plomley 1983: 187-188). In any case, the recovery of numerous bone tools from the Pleistocene cave sites has added considerably to Jones' 1971 inferences, although points are absent from some sites (e.g. ORS7 and Nunamira).

Bone tools make an early appearance in the archaeological record of late Pleistocene Tasmania, dated to between 31,610 ± 370 and 27,160 ± 250 years ago at Warreen Cave (Cosgrove 1999: 382)). Many are clearly shaped into needles, and the polished ends of such tools in Tasmania point to a likely function in the manufacture of animal-skin garments (Cosgrove 1993: 167, Cosgrove 2004: 60). It seems generally accepted that humans would have needed more thermal protection in the late Pleistocene than that afforded by the scant garments observed ethnographically among the Tasmanian Aborigines (Cosgrove 1997: 54).

**Stone tools**

The lithic toolkit of the Tasmanian Aborigines at the time of European contact was characterised by its sheer simplicity, both in terms of the form of the tools themselves and the number of formal tool types (McCarthy 1976: 84-85). Simplicity of tool form, however, need not necessarily relate to simplicity of function, and it cannot be taken to indicate relative cultural simplicity (e.g. White 1977: 22-27). The late Pleistocene lithic evidence from Tasmania certainly highlights this issue, with the development of more elaborate tool forms, notably so-called "thumbnail scrapers".

The first such tools recovered in the southwest consisted of sixteen small to medium flakes from Beginners Luck Cave, dated to around 21,000 years ago, and speculation as to their likely function at the time centred on food processing (Murray *et al.* 1980: 146-147). Like bone tools, thumbnail scrapers begin to appear during the early part of isotope stage 2 in the southwest. The earliest published dates are from Pallawa Trounta in the centre of the region, between 29,800 ± 720 and 27,250 ± 530 years ago (Cosgrove 1999: 375). Also like the bone tools, these small retouched flake implements may have served in the production of animal skin garments. Similar tool forms have been found in late Pleistocene contexts on the southern mainland (Cosgrove *et al.* 1990: 71). There is ethnographic evidence for the use of stone flake tools in the preparation of possum-skin cloaks on the mainland, although mussel shells and pointed bones were also utilised (Mulvaney 1975: 90-94). In the southwest of Tasmania during the late Pleistocene, the raw materials available for cleaning and preparing animal skins may have been somewhat limited by comparison to the southern mainland during the late Holocene, although the sharp edges of mollusc shells were available on the coast and were utilised by humans to make scraper tools. At Mannalargenna Cave, on Prime Seal Island in the Furneaux Group off the northeastern coast of Tasmania, the archaeological sequence extends from around 20,500 to 8,000 years ago. There are

well-made fossil shell scrapers, some stained with red ochre, along with a small bone spatula, and the stone tool inventory consists mainly of small flake tools and a few scrapers including a single quartz thumbnail scraper. Despite ochre-staining and the relative paucity of trees in the vicinity during most of the period that the site was occupied (and for which the lack of possum remains in itself provides corroborative evidence), the shell scrapers are said to be "tool types most commonly associated with wood working", while inferences as to the functions of the stone tools include the preparation of animal skins (Brown 1993: 265-266). Outside the southwest zone proper, thumbnail scrapers are not reported from ORS7 to the east, although they are present at Parmerpar Meethaner and Mackintosh to the north (Cosgrove 1995a: 93).

These distinctive stone tools disappear from the southwest by the end of the Pleistocene (ibid), although they persist into the Holocene elsewhere on the island (Freslov 1993: 235-236, Moore 2000: 71). Tools such as thumbnail scrapers would be expected to find many uses from the outset, and even to change their predominant functions over time, more so perhaps than bone points, and wood-working in particular might have become more prominent from the early Holocene as forests spread over the island. It is the timing and location of their initial appearance that is most relevant in this context, and this, it is argued, is consistent with the development and elaboration of clothing production during the late Pleistocene.

Residue analysis by Fullagar and Loy on a Kutikina thumbnail scraper revealed collagen and haemoglobin, with the latter identified as belonging to Bennett's wallaby, and some of the marks near the edge "were probably caused when the tool was used to scrape and cut skins" (Fullagar, quoted by Ranson, in Jones 1987b: 43). Use-wear analysis was performed by Fullagar on twenty tools from Kutikina, the majority being "thumbnail" scrapers. Multiple functions were identified, sometimes on a single tool, including hide preparation in approximately half the cases (Fullagar 1986: 348-350). The number of tools examined was small, and it can be noted that Kutikina was occupied between around 20,000 and 15,000 years ago, well after the earliest cave sites in the region. Nonetheless, it indicates that hide-working was among the functions of these tools during the late Pleistocene.

**Faunal targeting**

The faunal data from late Pleistocene Tasmania yielded another surprise for prehistorians, namely evidence for the "targeting" of a single animal species, the red-necked (or Bennett's) wallaby (Jones 1990: 283). This has a striking parallel on another land mass, namely ice age Eurasia, although the species targeted were different. In both areas, the targeted species yielded warm hides that would be useful in clothing; in Tasmania's case, the fur of the wallaby "would have provided excellent thermal insulation" (Cosgrove 1997: 54). Possums were scarce in southwest Tasmania during the late Pleistocene, presumably due to a shortage of trees. Their remains are "notable by their absence" at the five cave sites reviewed in an interim report of the SFAP (McNiven *et al.* 1993: 221). Overall, about 70% of the faunal remains are those of Bennett's wallaby and 5% are wombat, while the rest (with the exception of platypus) were probably accumulated largely if not exclusively by non-human species such as owls and marsupial carnivores. The species hunted by humans offered furred skins as well as food, although the extent to which they were "targeted" – that is, whether they are present in significantly higher proportions within the archaeological deposits than were present in the local environments – is difficult to establish. It should be noted that "very few bones of wallaby" were identified at two sites outside the southwest zone, ORS7 and Parmerpar Meethaner (Cosgrove 1999: 387), where wallabies may have been less numerous. The faunal evidence does however provide other indications that thermal considerations were an important element in the human exploitation of these animals during the late Pleistocene. First, there is evidence that the long bones were deliberately broken open to extract the marrow. Second, there is evidence that the frequency distributions of animal body parts at archaeological sites reflect separation of the skins to make cloaks, and also removal of the tails to extract sinews for use as thread in sewing the skins together to make the cloaks, as discussed below.

**Dietary requirements**

With respect to marrow extraction, for which there is little or no evidence elsewhere in Pleistocene or Holocene Australia (McNiven *et al.* 1993: 221), the leanness of wallaby meat placed a greater emphasis on exploiting what few fat-rich food resources were available (Jones 1995: 436). Marrow extraction highlights the thermal issues, with available food resources offering little by way of fat, at a time when human caloric intake needed to be much higher to sustain the elevated metabolic rates required for human survival in cold environments. There is also evidence in the faunal analyses, again with no ethnographic counterpart, for an over-representation of cranial elements during the LGM, suggesting that "the fat contained in the brain was targeted in addition to the marrow cavities of the limbs" (Cosgrove and Allen 2001: 413).

A focus on fat-rich foods raises the question of whether there was seasonal exploitation of coastal areas, where such resources would have been readily available during the late Pleistocene. Fur seals for instance offer a high-calorie food resource, as well as fur skins that would have been an attractive proposition for human hunters at the time. Such animals represent easy prey, and their skins were highly prized by European visitors who established a Bass Strait fur seal industry even prior to the first white settlement in Tasmania. The furs were shipped to Port Jackson (e.g. Collins 1802: 196) and then exported to Europe. For Aborigines in Pleistocene Tasmania, an ecological strategy centred on marine resources would have definite dietary

advantages. For this reason, it has seemed puzzling that they should have hunted wallabies in the highlands, especially during winter (Cosgrove *et al.* 1990: 74). Faunal evidence for the seasonal utilisation of the southwest includes the absence of remains of very young wallabies, suggesting that humans were not present in the region during the late summer and early autumn (Cosgrove and Allen 2001: 422). If so, they were presumably located along the coast, where most of the evidence for their summer sojourns will be accessible only to marine archaeologists (Jones 1995: 437-438).

### Animal skins

The other feature of the southwest faunal data of special interest in a thermal context is the evidence from body part frequencies suggesting the use of wallaby skins as cloaks:

> *While the data are too coarse to reveal specific butchery events they tend to support previous observations on prey body part selection... Certainly the low frequencies of numerous body elements such as the hard carpels, tarsals, phalanges and caudal chevron bones suggest to us that differential field processing and transport are reflected in these sites. These bones are the hardest and most numerous in the macropod body and likely to survive better than almost any other element. Apart from identification error, possible explanations include the removal of feet and paws at butchery sites away from the caves and the removal of tail sinew, both associated with removing the skins. The data thus suggest at least two processes in wallaby utilisation, firstly the detachment of distal limb bones as riders on the skins, and secondly the selection of marrow bearing long bones and cranial elements for nutrient extraction*
>
> (Cosgrove and Allen 2001: 413-418)

The deliberate separation of the skins from the carcasses – for which tools like thumbnail scrapers would be particularly effective – is without much by way of ethnographic parallels in Tasmania. For example, Robinson's journal entry for 11th December 1831 includes the following account:

> *The animal is first thrown on the fire whole as is their custom with all animals, and when the hair is singed they take the carcase off the fire and rub off the scorched hair with their hands. This practice is tenaciously observed with all animals except the opossum; the fur of this animal is first pulled off previous to its being placed on the fire*
>
> (Plomley 1966: 548-549)

Even possums, a favoured prey of Tasmanian Aborigines away from the coast, and whose fur was used to make cloaks by Aborigines on the southern mainland, do not appear to have been skinned prior to roasting on fires (Davies 1846: 413-414). The low frequency of carpal and tarsal bones and phalanges in the archaeological deposits may be due to them still being attached to the skins, with the paws serving to assist in tying or otherwise securing the cloaks around the wearer, which would have been more important for thermal reasons in the colder and windier conditions of the late Pleistocene. The paucity of tail bones suggests that the tails were removed whole with fur attached, or left attached to the rest of the skin (Cosgrove 2004: 60), serving perhaps either as decorative tassels or to help tie the skins together or to the wearer's body. Similar separation of distal bone elements is documented in ice age Europe, as shown below.

In summary, the archaeological record of late Pleistocene Tasmania provides evidence for behavioural adaptations to colder conditions, including various archaeological "signatures" of clothing. As such, it demonstrates how prehistoric clothing may be rendered archaeologically "visible" despite the garments themselves being invisible. The evidence is consistent with the development of "simple" rather than "complex" garments, as expected on thermal grounds. The recovery of bone points from many of the sites suggests that these draped (rather than fitted) garments were more substantial than those observed ethnographically in use among Tasmanian Aborigines during the late Holocene, again as may be expected on thermal grounds. The use of fitted garments during the LGM cannot be excluded, though the palaeoenvironmental reconstruction indicates that the development of "complex" clothing was not necessary for thermal reasons. Furthermore, some of the likely archaeological signatures of such clothing – dedicated cutting implements such as blade tools to cut hides into particular shapes prior to joining, and eyed needles to facilitate finer sewing in the manufacture of undergarments – are conspicuously absent in Tasmania. However, it should be emphasised that not all of the alleged clothing signatures seen in late Pleistocene Tasmania occur at all of the sites. As mentioned earlier, neither thumbnail scrapers nor bone points for instance were found at ORS7 and bone points were absent at Nunamira, while comparatively few remains of the "targeted" prey species – Bennett's wallaby – were recovered from ORS7 and Parmerpar Meethaner, both of which lie outside the southwest zone.

### Tasmania and ice age Europe

Comparison with the late Pleistocene archaeological records in middle latitudes of the northern hemisphere was advocated by Jones (1990: 290). Palaeoenvironmental data for Eurasia can be used to evaluate trends such as site utilisation and aspect, faunal targeting, clothing-related technological developments, and geographical limits to human occupation of cold environments. Thermal conditions in Tasmania, however, were less severe than in mid-latitude Eurasia, where mean LGM temperatures declined by around 12°C, and in some areas possibly by as much as 15°C below present. Sub-zero mean annual temperatures, and winter means below -5°C, signify that a further physiological threshold was crossed at middle latitudes in the

northern hemisphere. This has implications for minimum clothing requirements. Such conditions required more than two "clo" units of protection (Gagge et al 1941:429), and correspond to present-day 3-4 layer "clothing zones" (Siple 1949: 408-420, Griffiths 1976b: 80-81). These latter demand "complex" clothes (i.e. fitted, multi-layered garment assemblages), which have certain technological and archaeological correlates such as dedicated hide-cutting implements, i.e. blade tools, and an ability to safely inhabit sub-polar and polar latitudes (Gilligan and Walker n.d.). LGM conditions in Tasmania are not commensurable with the northern hemisphere isotope stage 2, but rather with earlier, less severe periods when mean temperatures fell by between 5°C and 10°C, such as stage 5b, around 90,000 years ago, and stage 4 around 75-60,000 years ago (cf. Jones 1982: 213, Kiernan *et al.* 1983: 31). It is to these earlier periods that Tasmania can be compared, in terms of the conditions to which prehistoric humans were exposed, and in terms of the technological correlates of clothing that may be anticipated in the archaeological record.

In the European context, the upper palaeolithic is associated with an expansion of bone technology, and with its elaboration in the guise of numerous specialised forms such as barbed spearpoints and eyed needles, which are not seen in Tasmania. From a thermal perspective, the technological comparison should probably be with the middle rather than the upper palaeolithic, where the emphasis was more on the production and refinement of stone scraper tools. This is indeed what is seen for the lithic technology in Tasmania during the late Pleistocene, as would be predicted on thermal grounds alone.

In the case of late glacial Europe after 35,000 years ago, environmental conditions were such that additional thermal protection was required for human survival. This took the form of "complex" clothing, *i.e.* fitted, multi-layered clothing assemblages, for which cutting tools (in the form of blades) and hide-piercing implements (in the form of bone points) were required. The former tool class was not required by humans in Tasmania at that time, as the necessary level of protection was afforded by "simple" clothing, *i.e.* draped garments, which did not need to be closely fitted for thermal reasons. The same applied among Neanderthals in Europe during the lower pleniglacial (isotope stage 4), whose stocky body build was also better suited morphologically in terms of cold tolerance than was the tropical body build of the fully modern humans who succeeded them.

With respect to bone tools, the need for bone points or awls in the manufacture of garments arose in Tasmania not because they had to be fitted, but because the smaller hides available in the form of wallaby skins (along with the furry skins other small animal species such as wombats, platypus and potoroo) needed to be joined together to make adequately-sized draped cloaks. Whether larger species such as *Diprotodon*, *Macropus titan* or *Sthenurus occidentalis* were also available during the period of human occupation is unclear (Murray 1978: 127-128), but the total absence of such faunal remains in Tasmanian archaeological contexts suggests their local extinction prior to the arrival of humans in the region (Cosgrove and Allen 2001: 424-425).

This was not the situation in Europe, where there was a plentiful supply of large fur-bearing animal species, whose single hides could provide adequate body coverage without the need for hides to be sewn together. The acute need for bone awls arose only among fully modern humans, when hides had to be cut into smaller segments and particular shapes that were then joined together to form fitted garments. Eyed needles, incidentally, are not associated with the use of fitted garments *per se*, as is commonly supposed. Instead, they reflect an emphasis on the finer sewing required for making the fitted undergarments in the multi-layered clothing assemblages. These considerations did not pertain in the thermal environments of late Pleistocene Tasmania, where draped single-layer garments assembled from the skins of small animals sufficed, and neither eyed needles nor blade tools appear in the archaeological record. With regard to blade tools, a similar "mobility" model to that proposed for the appearance of thumbnail scrapers in Tasmania has been proposed to explain the spread of blade tools in the upper palaeolithic of Europe. In the latter case, it has been acknowledged that the coincidence of such tools in industries with numerous bone awls may suggest some connection with the manufacture of clothing (Sherratt 1997: 283).

The faunal record in Tasmania also bears a comparison with ice age Europe, both in terms of the "targeting" of certain species and the more specific evidence for the selection and processing of raw materials in the manufacture of clothing. Evidence consistent with separation of animal pelts from the carcass occurs, for instance, at many upper palaeolithic sites:

> *Although Mousterians and even earlier people had adapted to glacial climates in central and western Europe, late Paleolithic people were the first to inhabit the harsh environments of easternmost Europe and northern Asia... where winters were exceptionally long and cold even during interglacials. Winter clothing almost certainly incorporated fur, and east European Upper Paleolithic sites including, for example, Mezin, Mezhirich, Eliseevichi I, Avdeevo, and Kostenki XIV have provided the oldest known evidence for systematic fur trapping... The remains of wolves or arctic foxes are extraordinarily abundant in these sites, and they tend to occur either as whole or nearly whole skeletons lacking the paws or as articulated paw skeletons, occurring separately. The implication is that the people removed the feet with the skins, as modern trappers often do, and then discarded the skinned carcasses. The "awls," "punches," and other pointed bone objects that appear in even the earliest Upper Paleolithic sites could have been used to sew skins together...*
>
> (Klein 1999: 535-536)

As Jones and others have suggested, the archaeological record of the Tasmanian Aborigines presents an ideal opportunity for making large-scale intercontinental comparisons:

> *What is much clearer now is that we have an independent test situation with [which] to investigate the dichotomy between environmental and behavioural explanations raised by the European data. Some factors are similar – early behaviourally modern humans, high latitude glacial conditions – while others, like the variety and ecologies of the prey species, are particularly different. While we do not have an equivalent of the Middle Palaeolithic for comparison, in the Tasmanian case any specialisations or efficiencies which might be apparent in the data cannot be related to the appearance of a more elaborate blade tool technology, as is done in Europe, because it is absent throughout the Tasmanian prehistoric sequence...*
>
> (Cosgrove and Allen 2001: 399)

Intercontinental comparisons between the archaeological records of peoples who had no direct or indirect contact with one other, who lived in different environments and even at different times, but who nevertheless developed similar technologies (or did not develop them), are useful in testing competing explanatory models for past behavioural and technological change. In the case of the tool forms discussed above, it is argued here that an enhanced capacity to survive in colder environments is one utilitarian function of such tool forms where greater effectiveness can be shown to correlate with the advent of these technologies. Similarly, the faunal records of widely separated regions, and other classes of archaeological data, are amenable to analysis in relation to thermal parameters. Moreover, the application of thermal data (physiological and environmental) allows such a model to be readily tested in every situation where such data are available.

# Chapter 13 Conclusions

The findings of this research indicate that the Tasmanian clothing paradox was, ethnographically, a reality. Their use of indigenous clothing was less than that which European observers could reasonably anticipate, given the environmental conditions (and given the observers' limited knowledge of human thermal physiology at the time). The Tasmanians also used less clothing than their Aboriginal contemporaries on the southern mainland, where this study has demonstrated a clear thermal trend of increased clothing with increased exposure to colder conditions. The latter finding points to an essentially thermal pattern of indigenous clothing use in Aboriginal Australia, and the reversal of this thermal pattern south of Bass Strait substantiates the existence of a clothing paradox in Tasmania.

This paradox has been explored in relation to principles of human thermal physiology. One aspect in particular offers the prospect of resolving the paradox. This is the role of biological adaptations to cold, the development of which can reduce any thermal need for clothing. A study utilising an environmental re-analysis of Birdsell's morphometric data base, in conjunction with osteological data, reveals evidence for the emergence of morphological cold adaptations in cooler regions of the mainland, with the results for Tasmanian Aborigines suggesting greater morphological adaptation to cold in this isolated southern group. Other thermal considerations include the ability of exposed humans to become habituated to levels of cold approaching (but not exceeding) the known limits of cold tolerance, together with higher environmental moisture levels and the protection from wind chill afforded by vegetation cover in Tasmania. These tangible factors are seen collectively as representing sufficient reason for the Tasmanians' comparatively minimal use of clothing at the time of European contact.

Thermal conditions in Tasmania during the last ice age deteriorated to the point where the Aboriginal inhabitants were exposed to critical levels of cold, levels that not only would have increased environmental selection for morphological adaptations, but would have required them to instigate behavioural strategies in order to survive, especially in winter. These behavioural measures included making use of natural shelter in the caves and rock shelters that were available in the southwest corner of the region, and also the use of more substantial clothing.

It is concluded from the ethnographic evidence that the Tasmanian Aborigines used neither more nor less clothing than they needed, which happens to be less than what was needed by some Aboriginal groups on the mainland. As such, the Tasmanian ethnographic record accords with an overall thermal pattern of clothing use in Aboriginal Australia. The ethnographic paradox, in other words, may be resolved. These findings, it is suggested, have broader anthropological implications, of which the most obvious relate to general theories of clothing origins.

It is concluded from the prehistoric evidence that the Tasmanians developed more sophisticated clothing during the last ice age. This has two implications. One is that they abandoned clothing after the ice age, in contrast to most other human groups. The other is that, archaeologically, prehistoric clothing is neither as invisible nor as irrelevant as is generally presumed.

The abandonment of clothing by Tasmanian Aborigines during the post-glacial epoch is perfectly explicable as a thermal adaptation, and as such it is consistent with the ethnographic picture. It does, however, raise the question of why some human cultures could readily dispense with clothing when it was no longer needed for reasons of warmth, while others, now the vast majority if not the totality of human cultures, find clothing indispensable for a multitude of reasons, some of which have yet to be fully fathomed. The answer, it is intimated, lies in the development of what is herein termed "complex", as opposed to "simple", clothing.

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